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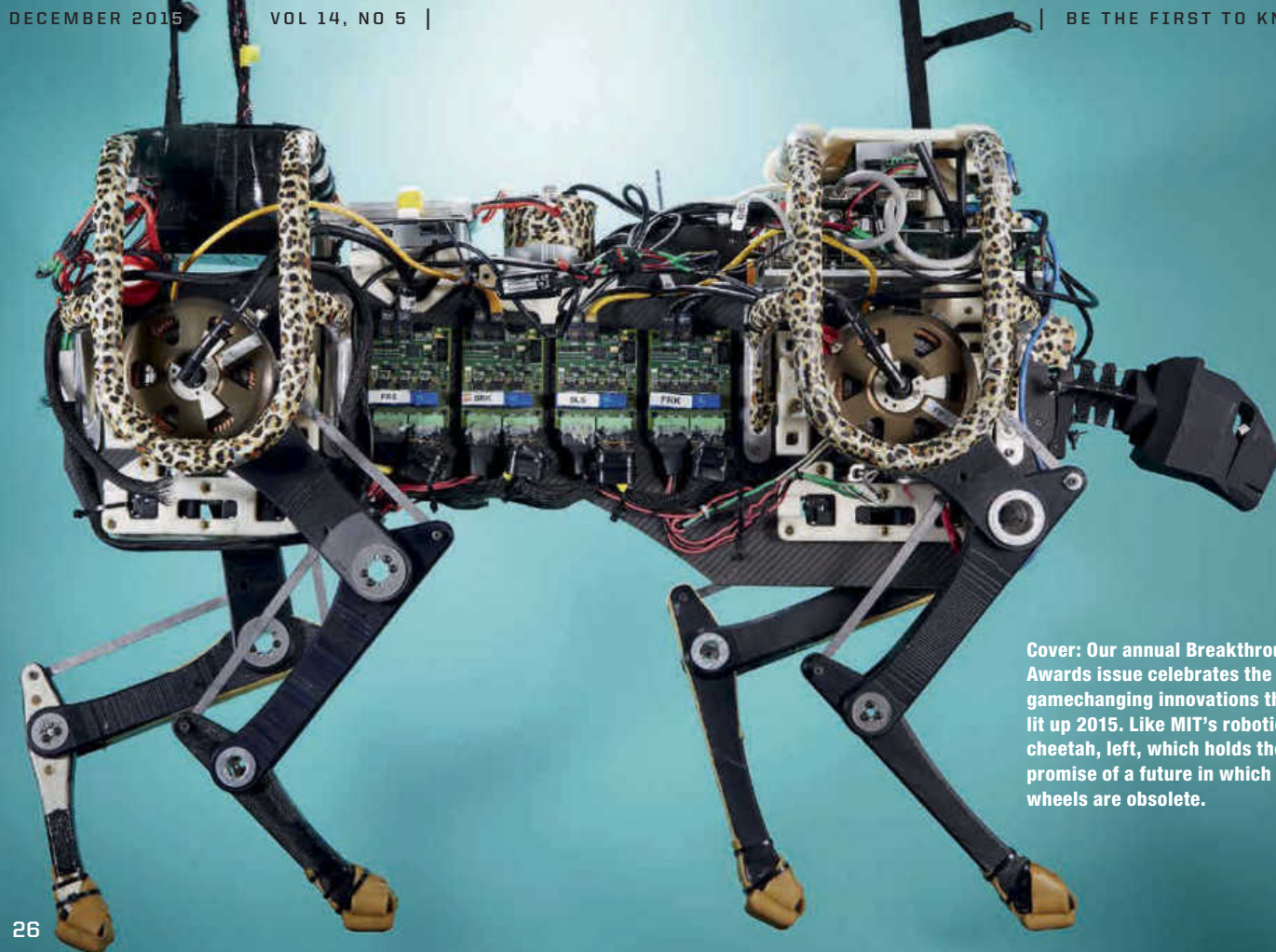
CONTENTS

**Popular
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DECEMBER 2015

VOL 14, NO 5 |

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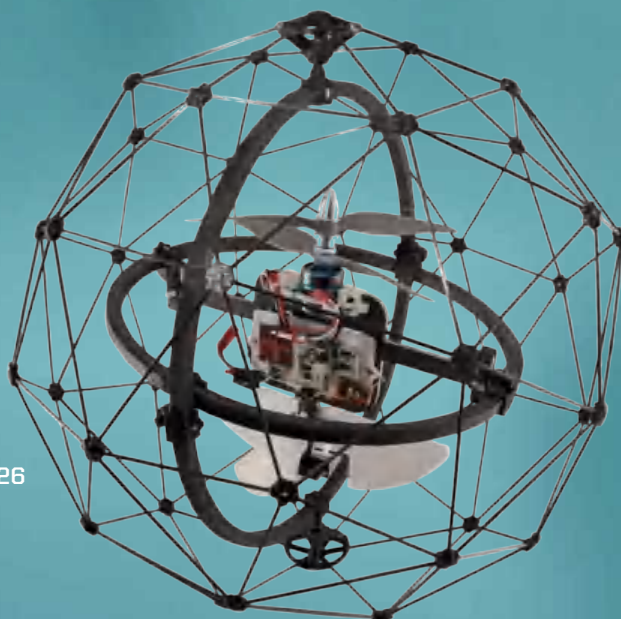


Cover: Our annual Breakthrough Awards issue celebrates the gamechanging innovations that lit up 2015. Like MIT's robotic cheetah, left, which holds the promise of a future in which wheels are obsolete.

26



74



26



70



TESTED 46

78



16



HOW YOUR WORLD WORKS

- 16 • **The forever spacesuit**
How the Smithsonian is restoring Neil Armstrong's Moon walk suit
- A slasher flick for 2015
 - Plasma actuators
 - The Jimi Hendrix Stratocaster
 - Africa Code Week 2015

FEATURES

- 26 **Breakthrough Awards**
- The next robotic hand
 - The fight against cancer continues
 - Sea monitors
 - Shutterbug space probe
 - Brain wave-controlled prosthesis
 - Inspiring kids to become engineers
 - **The Underdog**
Despite being outgunned by large corporations, Dave Masten might be building the next great spacecraft

- 52 **Water of life**
Is South Africa doing all it can to conserve this resource?

SCIENCE

- 66 **Cracking the code**
Quantum computing could turn cryptology – and with that, data security – on its head
- 70 **Life 2.0**
Innovative Deep Brain Stimulation raises hope for Parkinson's – and more

TESTED

- 46 • Lantern shootout
- Asus Zenbook UX305
 - Sphero BB8 droid
 - Huawei P8
 - TomTom Bandit



66

WHEELS

- 78 • Don't kill the diesel
- **PM Drives:**
Toyota Auris HSD
Tata Bolt Hatch XT
Peugeot 208 GT Line Auto
Ford Ranger XLT
 - Welcome to the crash lab
 - Toys

TECHNOLOGY

- 60 **Say it with flowers**
Florists, trained monkeys and Bitcoin: new takes on e-commerce
- 64 **At watt cost?**
To conserve energy properly, you first need to know how much you're using
- 74 **Look smart**
Next-gen wearables can recognise you – and shape-shift for cooling or heating

SKILLS

- 89 **The most useful tools in your kitchen**
How to buy knives
Things come apart: Electrocardiograph
Kid's project: Marble run

MONTHLY

- 4 Credits
- 6 From the Editor
- 8 Letters
- 14 Time machine
- 112 Do it your way



52

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(See page 85 for details).

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WATER: THE FRONTLINES OF THE WAR ON CLIMATE CHANGE

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JIMI HENDRIX, PM MAN

You could call it Pop Mechness: that blend of genius, practicality and idiosyncrasy. Which makes Jimi Hendrix the epitome of Pop Mechness. (The ability to make a guitar scream, sob and practically disembowel the listener also helps.)

Back in the days when I had long hair – well, when I had hair, period – I, too, played a Fender Stratocaster. More of a rock or bluesman's axe, it may not have been the ideal choice for a jazz-funk band. A battered ancient specimen of the breed, it wasn't white like Jimi's; what was left of its finish seemed more cloudburst than sunburst. At least it was a genuine Strat and it was in the band's equipment pool.

My nostalgia trip kicked in when I flipped through this month's HYWW* and found the feature on the remaking of a guitar legend, the Jimi Hendrix Fender Stratocaster. Turns out left-handed Jimi's unorthodox choice to play a right-handed guitar upside down and strung for left-handed playing not only solved the practical problem of instrument availability, but also helped create his unique sound. Which is why the set-up is being replicated, 45 years after his untimely death.

I like to think that my own mildly fussy rhythm technique and earnest solos on the Strat made a modest contribution to the musical development of the guys (they were almost always guys) with the puppy-dog look, lined up near the stage or bandstand instead of dancing. It was obvious that, besides being music geeks, these onlookers were also dorks, hence not deemed suitable dance-partner material. Come to think of it, that possibly described me, too, which is why I was hiding behind a guitar and not mingling with the hot... er... female patrons.

My career trajectory didn't quite reach the heights of those many guitar legends associated with the Strat, some of them listed on Page 20. Besides, I always had a thing for nylons (that's nylon strings, by the way), archtop cut-aways and the mellowness of jazz.

Still, I have fond memories of my Strat for the way its punchy midrange and plangent top end cut through the haze of what I suspect wasn't entirely tobacco smoke. At least during the times when my temperamental amp was actually working.

* How Your World Works. But here at PM we like to think of it as being short for HeY, shoo WoW.

Anthony

anthony@ramsaymedia.co.za



Sorry, Jimi: the archtop means I'm channelling my inner Wes Montgomery these days.

PHOTOGRAPH BY KIAN ERIKSEN

COMPETITION WINNERS. Details online at www.popularmechanics.co.za



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BLAME THE LED TRANSFORMERS

The problem experienced by Robin Hayes ("LEDs spoil the tune", November 2015), is probably being caused by the step-down transformer associated with all standard household LEDs. This transformer, used to assist with 12-volt operation on a 220-volt grid, creates a frequency interference with his radio signal.

That's a quandary with switchover to LEDs. The LED has a lifetime of about 10 000 hours, but invariably the transformer part fails first, which necessitates replacement of hugely costly lights way before the expected time. Besides, additional electricity consumption is involved in the losses experienced with transforming from 220 volts to 12 volts.

What I have done is to source 12-volt LED lights directly and install them through the house on a dedi-

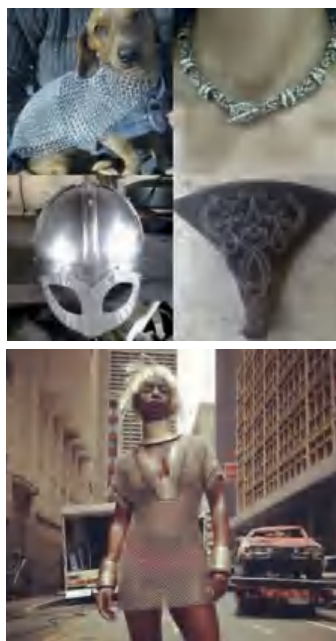
cated 12-volt line from the distribution board, supplied by a rechargeable battery that is simultaneously connected to a battery charger. So, if a rolling blackout comes by, my lights aren't affected at all.

Caution should be applied when installing the LEDs, though. Lighting wire from the distribution board is standard at 1,5 mm square. That can safely carry 7,5 amps, being equal to 90 watts at 12 volts. So, when fitting LED lights, take care not to exceed the safe limit of your wiring.

All the above must be with the assistance of a qualified electrician.

KOBUS STANDER
BY EMAIL

Send your letter to: **POPULAR MECHANICS**, PO Box 180, Howard Place 7450, or e-mail popularmechanics@ramsaymedia.co.za Please keep it short and to the point. Regrettably, prizes can be awarded only to South African residents.



ARMOUR AS JEWELLERY

After seeing my picture in your feature about Orusta, "A most violent hobby" (November 2015), I thought your readers might like to hear about the work that I do. At Samsmaile, as well as producing chainmail jewellery, clothing and oddities, we work with the finest artisans, weaponsmiths and armourers, at home and abroad, to produce historical and fantasy reproductions for our discerning clientele.

The composite image features our Bert modelling his maille armour, one of the many different kind of necklaces we make by hand, an authentically reproduced Norse helm by Robertson Armoury, and an Urnes etched Dane axe. The other image is a stainless steel maille dress we made for a Joburg designer, who was working for M-Net at the time. The model is Hlubi Mboya.

Find us on facebook (Samsmaile), or email us at samsmaile@gmail.com

SAM SPIERS
GAUTENG

THAT MYSTERY TOOL

Pictured with the November 2015 issue of Ask Roy was an unusual tool that needed identifying. Here's what you said.

THE ANSWER IS: It's a staple gun or nail gun. It might be for carpentry. - *JD Val*

OR MAYBE NOT: The mystery tool on page 90 of PM November 2015 looks to be a glazing point setter or point driver. The "point" is a fastener used to secure glass panes to a sash window. It uses a stack of small diamond-shaped plates loaded not unlike a pistol's magazine. It seems to be a Red Devil Glazing Point Setter from the 1800s. - *Marius*

SET THE STANDARD

Well done to all the staff, especially those who decided it would be a good idea to include a vehicle section. May I suggest that, when in future you do an article such as "The little van that can", you standardise the specification section so it is easier for the reader to compare vehicles.

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Premium tyre



Budget tyre



+ 4 vehicle lengths



For instance, you have load space and also cargo space and load volume, which is given in linear dimensions, cubic metres or litres. I know I can go and work it out, but if you standardise the specs it makes for far easier reading and comparisons.

JAN MINNIE
BY EMAIL



LUGGING LOADS, 1970s STYLE

Jordan Gianno's Amandla wheelbarrow (Gaining Leverage, October 2015) is reminiscent of a patent owned by Williams Brothers in the early 70s for a "Lite lift" wheelbarrow. Williams Bros was bought out by Ussher Inventions Pty Ltd, which now owns Lasher Tools. The product may have been discontinued, as it does not appear on the website. For the ultimate in effort reduction, I noticed that there is a powered version, which even tips, too

My comment about a design of this type is that, although positioning the wheel under the load does make a barrow easier to lift, it also raises the centre of gravity and reduces standing and lateral stability. So there is a compromise to be made in the design characteristics and unfortunately all of this adds cost.

It's great to keep challenging and improving everyday things – good luck, Jordan!

PETER HAMILTON
BY EMAIL



A BETTER BARROW

I have news for wheelbarrow inventor Jordan Gianno. In my backyard I have variation of his Amandla, some 40 years old, pretty stable and easy to operate. He might sort out his kinks in design by moving the acker points on the load bed of the barrow, as per the one in my photo.

FRANS MOHR
PRETORIA

YOUR OLDEST TOOL

Our October 2015 Time Machine feature on sharpening tools asked you to tell us about your oldest tool. Here are more stories from the toolbox. Next month, we'll announce the winner – and his prize.

MASTERING THE ART OF WOOD

I started my teaching career at Jeppe Boys' High, where a Mr Robson became my mentor in the industrial arts section. There I learnt to sharpen all tools and equipment within the framework of strict discipline and safety measures and deadlines – observed through 35 years of different workshops, from Plaaswerktuigkunde to industrial arts and even industrial design. (I am ex-head of industrial design, Technikon Witwatersrand, now the University of Johannesburg.)

1. Lumberman's Saw. Oom Jan from Bekker Skoolplaas gave me a double-handed Lumberman's saw in 1963. I sharpened all teeth with a triangular file, but could not use a saw-set because the teeth were too big. I therefore had to carefully bend the teeth in alternate directions using a hammer, obtaining a perfect setting of teeth.

A few matrices enjoyed a dark night out of the school hostel to help me, with the aid of a lantern and two candles, to cut a thick slice through the bottom end of a dry wild olive tree trunk – today an exceptional coffee table in my sitting room (see attached photo).

2. Ouvrou-se-tand (known in the UK as a router plane and in the US as a plough plane). This old special plane from my toolbox was used to cut a groove all round my woodwork benchtops to accommodate painted colour codes for the school workshop during 1964.



FLIP BRINK
BENONI

HANDED DOWN

I have two tools inherited from my father. The one that looks like a hook is used to replace the springs on the brake shoes on motor vehicles. It dates back to when he was an apprentice motor mechanic in 1943. The other tool like a pair of pliers was used by my grandfather on his farm to twist wire together when putting up fencing. I am not sure of the age, but it dates back to the early 1900s.

SCHALK RABÉ (REG. ING. TECH.)
AUCKLAND PARK



SKIM SAFELY

In "The skimming scheme" (Letters, November 2015), the writer forgot to include certain important information.

All manufacturers specify minimum disc thickness. They do the same for engine cylinder diameter. Although you should never ever skim outside these specifications, it

is perfectly safe to do so within the specification. If skimming would go beyond the specification, the parts *must* be replaced.

KEVIN SEYFFERT
BY EMAIL

(The original letter referred to was shortened, removing detail including some of what Mr Seyffert mentions. - Editor)

PM

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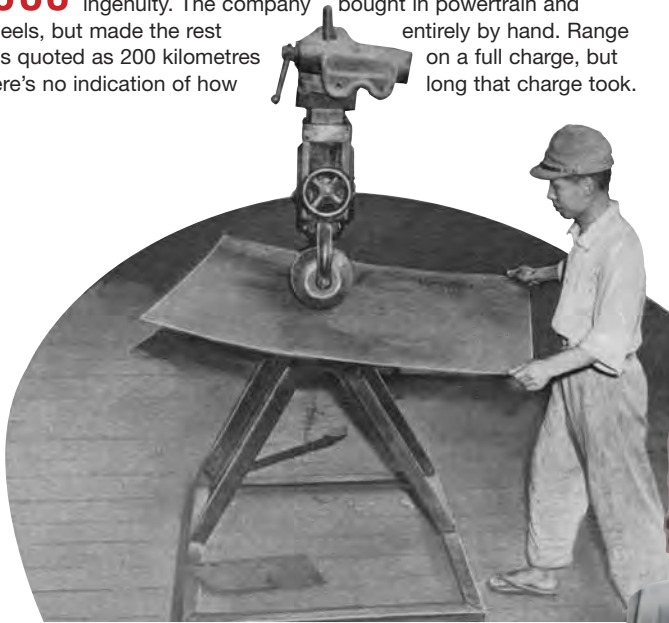


Das Auto.

May 1956

Perhaps foreshadowing the impressive current-day performance of Airbus, the May '56 cover story "French revolution in the air" details a host of prototypes, concepts and actual aircraft from France. One that never really got off the ground, commercially speaking, was the Coléoptère, pictured on the cover. Essentially a flying jet engine, it looked like a good way of achieving vertical take-off followed by level flight. There was one rather important objection, apparently: in the event that the engine failed, the crew would have no option but to bail out.

1950 Described as "Japan's postwar menace to the pedestrian", the Tama EV was an early example of Far East transport ingenuity. The company bought in powertrain and wheels, but made the rest entirely by hand. Range was quoted as 200 kilometres on a full charge, but there's no indication of how long that charge took.



1948 Product testing has become a fixture in the consumer media and PM is no exception to that. Besides providing good advice on your next purchase, we just love playing with tech stuff, the bigger the better. However, we'd draw the line at one testing method employed by the US Navy in post-WWII years. Our picture shows a Navy lieutenant walking towards the intake of a jet aircraft under full power to find out how close a man can get without being sucked in*. We can't help thinking that, safety line or not, the officer must have annoyed an admiral somewhere.

* About a metre.



1950 Disaster beckoned unless drastic steps were taken, warned this April 1950 story, "Are we running dry?". Increasing urbanisation – they called it growing pains – was said to be rapidly depleting the country's underground water reserves. Also mentioned was an Indian ghost city whose 200 000 souls moved out when the wells ran dry centuries ago, which only goes to show that water scarcity is nothing new.

PM

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ASTRONAUT GEAR

THE FOREVER SPACESUIT

The garment Neil Armstrong wore when he became the first man to walk on the Moon is deteriorating. Here's what the Smithsonian will do with the more than R9 million the public has pledged to fix it.

BY KEVIN DUPZYK

IMAGE BY MARK AVINO, NATIONAL AIR AND SPACE MUSEUM, SMITHSONIAN INSTITUTION



Conversation starters for smart people

To conserve weight for the journey home, Armstrong and the other astronauts left their life-support backpacks and Moon boots on the Moon. They're still there.

IF, AFTER THE SHELVEING OF THE SPACE SHUTTLE PROGRAMME, you feared that America had lost its adoration for space travel, this should help. In July, 46 years to the day after the first Moon walk, the Smithsonian's National Air and Space Museum in Washington, DC, started its first Kickstarter campaign, asking for money to preserve the spacesuit Neil Armstrong wore when he stepped off Apollo 11 on to the Moon in 1969. Designed to withstand solar radiation, drastic changes in temperature, and objects travelling faster than the speed of sound, the suit is failing miserably at surviving the inevitability of time. The campaign requested \$500 000 (about R6,6 million) to restore the suit before its unveiling at "Destination Moon", a permanent exhibit that will open in 2019. The goal was met in just five days. By the end of the campaign one month later, R9,6 million had been donated by more than 9 400 backers.

The Smithsonian could have raised this much money in the traditional manner, by schmoozing donors at galas, but in a way, asking the public for cash is appropriate. The Smithsonian Institution was founded with half a million dollars from a British scientist who never set foot in the United States, but wanted to create an institution for "the increase and diffusion of knowledge among men". That all-for-one spirit is the same as the one that pushed us to explore space in the first place. And though few of us will ever set foot on the Moon, the success of the Smithsonian's fund-raising effort proves that we'll spend the money to make sure future generations are still inspired by the effort it took to pull it off.

THE RESTORATION

Cathleen Lewis, curator of international space programmes and space-suits, and Lisa Young, objects conservator, explain how the museum will use the Kickstarter money to protect Armstrong's suit.

→ Rubber protection

When NASA built the suit, it was concerned with only one thing: getting the astronauts to the Moon and back. The suit designers didn't care about museum exhibits, so they chose to use a mix of natural and synthetic rubbers with a six-month life span. In fact, they couldn't order the suits too early or they would degrade before the mission was complete. Today the rubber has become brittle. Oxidation, UV radiation, and temperature are all factors in the deterioration, so a new display case with a ventilation system will stabilise the rubber at 18 degrees, 30 to 34 per cent relative humidity, and about 100 lux.

→ Removal of aluminium corrosion

The aluminium on the suit – primarily the red and blue buttons and arm disconnects – has oxidised and could become riddled with corrosion pits. Conservators have tested several removal options, including lasers, air abrasion, and old-fashioned hand tools. Everything they've tried has removed more of the original material than they'd like, so a portion of the Kickstarter money will be used to test corrosion inhibitors used in military and commercial applications. The compound they identify will be applied throughout the spacesuit collection, which includes 400 pairs of gloves with aluminium components.

→ Preservation of Moondust

Conservation isn't about making the suit "like new", but preserving the state it was in when Armstrong got home. Like any article of work wear, the suit needs a good cleaning, but the Moondust on the suit can stay. Conservators will use tweezers under a microscope or a tweezer vacuum, which uses a tiny suction tip to pick up delicate materials, to remove debris without disturbing the dust. This actually isn't so difficult: the lack of atmosphere on the Moon creates very sharp dust particles. These have embedded themselves deeper in the suit's fabric than a surface cleaning should reach.

→ Stripping of surface coatings

Sometimes past preservation is the enemy of current conservation. Protective coatings, such as those applied to Armstrong's suit before it was allowed on a post-mission tour, often break down before the object itself. Research will determine exactly what coatings have been applied – conservators suspect Teflon – and whether mechanical or chemical means should be used to remove them.

→ Support

The suit needs a mannequin to hold it up. But because the suit doesn't fully unzip, the mannequin has to be assembled inside it. Additionally, the support system needs to hold the gloves and helmet, which can't be attached – in part because residual lunar dust can lock up their couplings. Colleagues throughout the Smithsonian are building a prototype mannequin, which will then be replicated for the rest of the museum's spacesuits.

→ Ventilation

As materials in the suit break down, they undergo a process called off-gassing, in which they emit harmful chemicals in gaseous form. Rubber, for example, off-gases hydrogen chloride, which is highly acidic and damages other materials in the suit. To combat this, the suit's new display case will include a chemical scrubber to bond with the gases and pull them out of circulation. Finding a suitable scrubber will be a challenge, as the molecules conservators need to trap are much smaller than typical pollutants.



← **Smithsonian Institution objects conservator Lisa Young inspects aluminium fittings on Neil Armstrong's suit for the presence of chlorides.**

MOVIES

A SLASHER FLICK FOR 2015

In a genre that seems all but exhausted, one director had a crazy idea: why not shoot a horror film with a robot camera?

BY JACQUELINE DETWILER

THE DIRECTORS OF SCARY MOVIES employ a number of techniques to manipulate the audience's emotions – the close-up, the wide-angle, the long take, the jump cut. Todd Strauss-Schulson, director of *The Final Girls*, a campy meta-style horror-comedy, wanted to do something different. His idea was to mimic the characters' fear by producing a scene that tumbled and rolled like a visual panic attack. The problem: no human camera operator could perform the moves he needed, even on a crane. Instead, Strauss-Schulson, who had been experimenting with robotic cranes while making short films, rented a Genuflex MK III by General Lift, a programmable robot that can track two metres per second and swing, pan, tilt, and roll 360 degrees, all while automatically focusing a camera. It can also produce multiple takes with inhuman precision, repeating the exact same motions over and over within fractions of a millimetre, like a robot in a factory.

The Genuflex is primarily used to create visual effects – multiplying extras to create fake crowds, for example, and creating slow-motion shots of moving vehicles. Strauss-Schulson used it to follow six of *The Final Girls'* main characters while they attempt to use a booby trap to foil a maniac with a machete. Over three days in a humid cabin in Baton Rouge, Louisiana, the technicians programmed the crane to move through a shot, then established speed and focus. Next they ran each take at half speed so the actors could practise hitting their marks before the camera hurtled to within – in some cases – centimetres of their faces. "That's the fun engineering stuff," says Strauss-Schulson. "You worry: is the track long enough? Is it going to knock into the wall? Is it gonna hit that guy over there?" Finally, the staff got each of four shots necessary to complete the scene – full speed, with no actors knocked unconscious. The MK III's engineers, accustomed to planning dull technical shots, had a blast. The resulting paroxysm of an action sequence, one that would be easy to adapt to other movie genres, is novel and great. Also: pretty damn scary.



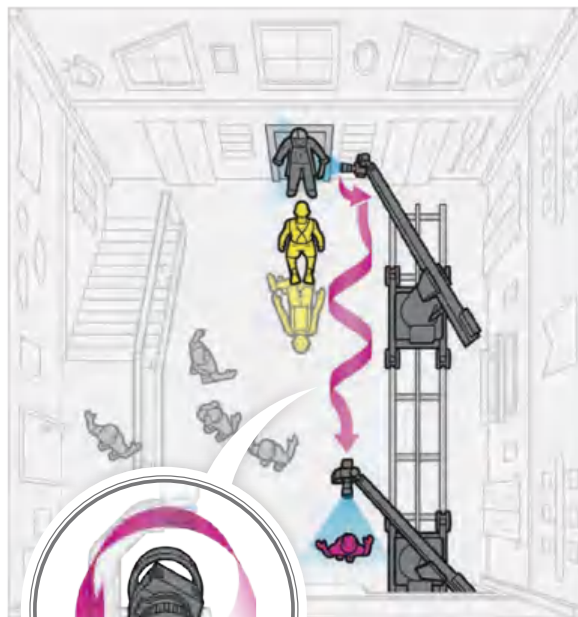
+ **HISTORY: AN UPDATE** The real-life friendship between humourist Mark Twain and explorer-of-Africa Sir Henry Morton Stanley so fascinated late Pulitzer Prize-winning novelist Oscar Hijuelos that he spent more than a decade researching and fictionalising it, working on revisions until the day before his death in 2013. The historical novel *Twain & Stanley Enter Paradise* is the result.



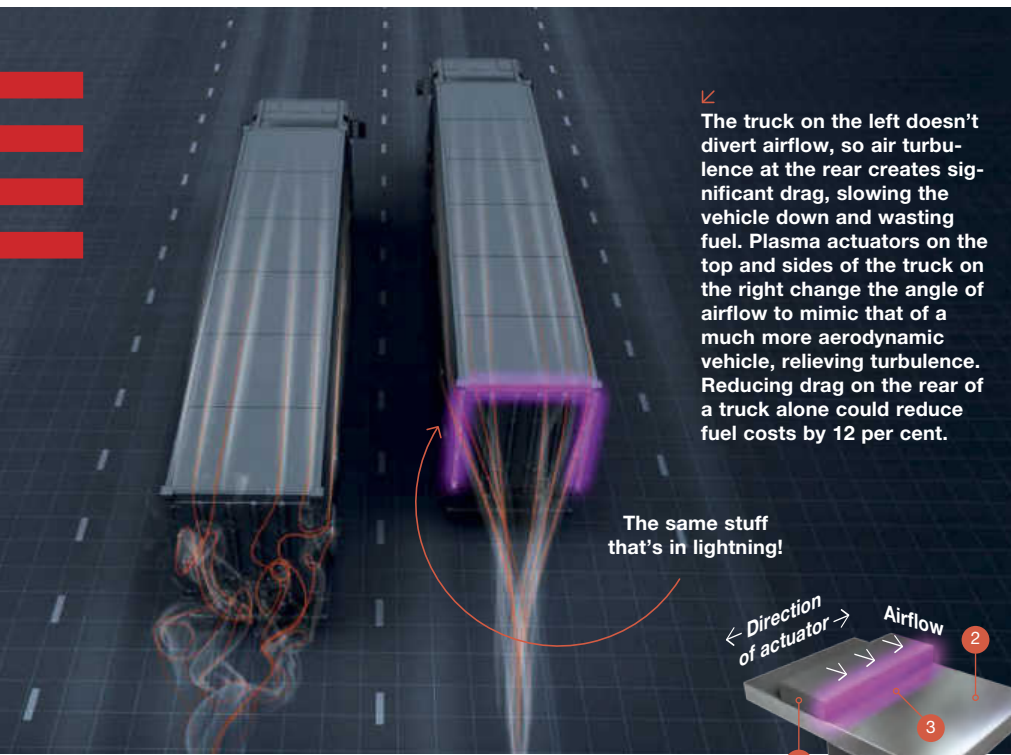
↑ The daughter of a horror-movie scream queen (above) becomes trapped in one of her mom's old movies in *The Final Girls*.

The robot take

A few of the motions the Genuflex MK III makes after the bad guy, Billy, stabs one of the main characters.

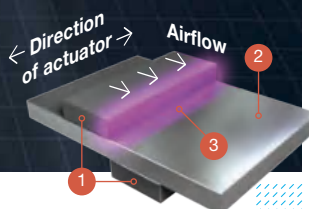


▲ In this movement, part of a 32-second take, the camera lifts and pans 90 degrees while performing two full barrel rolls.



↙ The truck on the left doesn't divert airflow, so air turbulence at the rear creates significant drag, slowing the vehicle down and wasting fuel. Plasma actuators on the top and sides of the truck on the right change the angle of airflow to mimic that of a much more aerodynamic vehicle, relieving turbulence. Reducing drag on the rear of a truck alone could reduce fuel costs by 12 per cent.

The same stuff that's in lightning!



1. Electrically charged copper plates
2. Insulating dielectric layer (such as Teflon)
3. Plasma

PLASMA ACTUATORS

Extremely complicated physics explained with the help of semi-trucks.

FORMULA ONE CARS are the vehicle world's birds of prey – sleekly exploiting aerodynamics to overtake weaker cars on the grid. Long-haul trucks, on the other hand, are built more like turkeys, as if drag, the air resistance that impedes a vehicle's motion, doesn't hamper semis the way it does race cars. Unfortunately, that's not true. Some 66 per cent of a semi-truck's fuel goes to combating drag. Plasma Stream Technologies, a company using science developed at the University of Notre Dame, thinks it has a solution: use a plasma actuator to alter airflow – turning a turkey into a hawk – without actually changing the shape of the truck. Sounds cool, but, uh, what's a plasma actuator?

According to Notre Dame engineering professor Thomas Corke, when an insulating material such as Teflon is sandwiched between two staggered, electrically charged copper plates, one exposed to air and the other trapped behind the Teflon, the surrounding air transforms into the fourth state of matter, plasma, which means that it develops an electric charge. The exposed electrode repels similarly charged plasma, pushing it towards the electrode with the opposite charge. As the plasma moves, it sucks neutrally charged air along with it, creating an air current the same way a fin or a spoiler would. – CAMERON JOHNSON

WHATEVER HAPPENED TO . . .

The ozone layer?

Surprise! It's still there.

REMEMBER THE 1980S, when the greatest threats to civilisation were crack cocaine, ozone depletion, and Spandex? We actually solved one of those problems. According to reports from the United Nations, not only is the ozone layer recovering, it could be restored to 1980s levels as soon as 2050. This good news is largely due to the Montreal Protocol, a treaty that banned ozone-depleting chlorofluorocarbons (CFC), often used in aerosol sprays and refrigerators, in 1987.

Hold those high fives, lovers of air. After the agreement many manufacturers replaced CFCs with hydrofluorocarbons (HFC), which lack the chlorine in CFCs that harms ozone, but still trap energy in the atmosphere, contributing to global warming. The situation is worrisome enough that the Obama administration recently mandated that any company able to switch to a safer compound must do so.

James Burkholder, a National Oceanic and Atmospheric Administration research scientist, says a likely substitute is a class of chemicals called hydrofluoroolefins (HFO). These have global-warming potential similar to HFCs but last only about a week. (In comparison, a common HFC refrigerant in cars has a lifetime of about 13 years.)

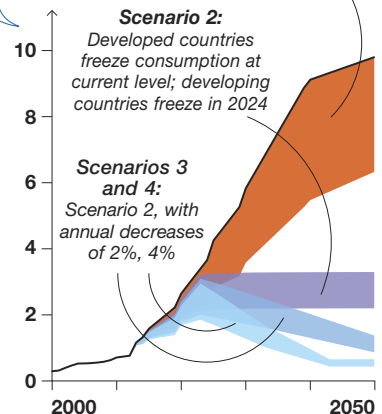
There's no set time line for the transition to HFOs. Manufacturers will have to modify their factories to work with the new compound, which could take years. In the meantime maybe scientists can eliminate more nefarious threats from the '80s, such as Tom Cruise.

– ANDREW DEL-COLLE

GLOBAL HFC PRODUCTION SCENARIOS

Carbon dioxide equivalent, a measure of potential global warming (in billions of tons per year)

Scenario 1: HFC consumption left unchecked



WILL PRINTING STUFF ALWAYS SUCK?

There's a special place in hell for the grifter who invented the printer cartridge. You buy this necessary gadget, run out of cyan ink at 02:00 the night before an interview, and next thing you know you're swiping your credit card under the sad fluorescent lights of an office supply store.

Thanks to Epson, you can now spend around R5 500 for an EcoTank printer, which has side-mounted reservoirs that hold a year's worth of

ink. It costs about half what you would pay for a cartridge-based printer over the course of its life. Take that, Big Printer!

It's a welcome advancement, but I'm still holding out for the day printing ends. Plane tickets, movie tickets, documents to be signed, all of that can be done with a smartphone now.

Printing is still essential for some tasks (shipping labels, for example), but I trust that one day it will disappear. Then we can save our clunky ink-jets for sending sonnets through the mail. – ALEXANDER GEORGE

MUSIC

THE JIMI HENDRIX STRATOCASTER

Backward. Awesome. And now you can buy it.

The world isn't fair to lefties, even when they're rock gods. Jimi Hendrix had a hard time finding left-handed guitars, so he flipped over and restrung standard right-handed Fender Stratocasters. That changed the string tension and microphone location and produced Hendrix's signature mix of bright highs and delicate lows. This month Fender is releasing a Jimi Hendrix Stratocaster (for \$900) that will mimic the legend's modifications. Here's how it works. —KEVIN DUPZYK

STANDARD STRATOCASTER

Fender's headstock design makes every string a different length, so restringing the guitar upside down changed which strings were longest. This altered the subtle overtones produced by vibrations on the unplayed part of the string above the top of the neck, near the tuning keys.

On a traditional Strat, the highest strings (E, B) are longest. Upside down they become the shortest, so they don't have to be pulled as tight to be in tune. For Hendrix that made them easier to bend, crucial for songs like "All Along the Watchtower".

For the same reason, Hendrix's low strings were comparatively tighter, which made them sound less booming and twangy.

Guitar pickups are like a set of mini-microphones, with a pole magnet aligned below each string. The distance between the magnet and the string varies for each string. By reversing the orientation of the traditional Stratocaster, Hendrix changed which strings were closest to their magnets and, consequently, most prominent in the mix.

The rear pickup on the traditional Stratocaster is slanted to capture the higher strings near their base, where they have a more piercing tone. On Hendrix's guitar it catches the higher strings farther up, so instead of shrieking, they sing.

JIMI HENDRIX STRATOCASTER

NEW!

STRAT LEGENDS (OTHER THAN JIMI)

Eric Clapton. The most famous of Slowhand's Strats, Blackie, was actually a lash-up of three different guitars. Fender's first Signature model was the Eric Clapton Stratocaster.

Dave Gilmour. Black was also the colour most associated with the Pink Floyd guitar player, though it was supplanted for a while by a Candy Apple Red model until being brought out of retirement. Gilmour owns Strat #0001.

Mark Knopfler. The distinctive sound of a red 1961 model provided the Eureka moment for the Dire Straights frontman. Stinging single-note lines and rippling arpeggios transformed his approach to what was to become a late 1970s landmark: "Sultans of Swing".

Hank Marvin. Said to have been the owner of the first Strat in England, the man whose tremolo-heavy technique is instantly recognisable as the sound of The Shadows is credited with influencing a legion of other Brits. Including, surprise surprise, David Gilmour and Mark Knopfler.

John Mayer. Mayer was singing the blues in more ways than one in 2014 when he split with longtime endorsement partner Fender, which had produced a Signature version bearing his name.



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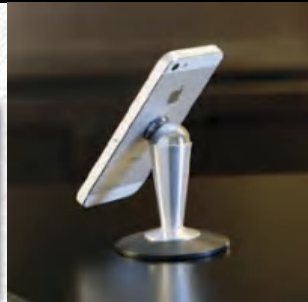
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EDUCATION

CODING'S COOL

Code is a new language... and every child deserves to be fluent. BY NIKKY OOSTHUIZEN

THE RAPID INCREASE IN ACCESS TO THE INTERNET across the African continent has boosted opportunities for employment and entrepreneurship. That's even more relevant in a business environment with an ever-growing dependence on software. At the same time, Internet access has created a challenge: children need to learn a whole new set of skills so they can survive the connected world.

In South Africa alone, individuals with Internet access numbered 24 million in 2014, from just 4 million in 2000. This increase in consumer access is reflected all over Africa, according to the quantitative research company, Ask Africa.

That's why, this past October, local schoolchildren were being shepherded through the intricacies of coding in the inaugural Africa Code Week. More than just about creating apps and animations, Code Week is a campaign that aims to get children interested in computer science while promoting critical thinking, problem-solving and teamwork. Targeting more than 20 000 children in 11 countries, Code Week was promoted by software giant SAP, in co-operation with Simplon.co, the Galway Education Centre, the King Baudouin Foundation and the Cape Town Science Centre.

It comes in the wake of the success of EU Code Week in 2014, which reached more than 150 000 children across 37 European countries. The African equivalent involved South Africa, Angola, Cameroon, Kenya, Ivory Coast, Nigeria, Senegal, Morocco, Tunisia, Togo and Egypt.

Using the programming language Scratch and under the tutelage of specialist volunteers from around the world, drawn from SAP's international offices, young children were taught how to animate, while older children were taught how to build a basic messaging application. Scratch is a free programming language from the Lifelong Kindergarten Group at the MIT Media Lab. It helps children to create interactive stories, animation and games. Globally more than 10 million projects have been created using Scratch.

By the end of the fifth year of Africa Code Week, the



Above: Khutbuddin Nefet (right) watches his project come to life, while Calen Whyte, a Cape Town Science Centre employee assists Luqman Sahib and Ali-Ridah Sahib with their projects. Left and top: This class was shown how to animate a cat using the programming language Scratch.

project hopes to equip more than 200 000 science teachers across the continent with the resources to educate children better. At the same time, they plan to reach more than a million children with these resources, as well as workshops.

"ICT is no longer part of our future. It is our present. In education, it is our responsibility to equip our children to be active citizens in our economy, and provide much-needed skills," Western Cape MEC for Education Debbie Schäfer said at the launch of the event in Cape Town. "There is a great need in South Africa for IT professionals. Africa Code Week assists in promoting this as a possible future career for our learners. It also promotes issues such as critical thinking, problem-solving and teamwork, all of which are crucial for success in life."

FAMILY HOLIDAY?

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GREAT UNKNOWN

Q

**BIG QUESTIONS.
ANSWERS YOU CAN'T
FIND ON THE INTERNET.**



How often do ambulances and fire engines cause accidents on their way to emergencies?

A **PRETTY OFTEN.** Though, in fairness, nobody tracks how many accidents involving emergency vehicles were actually *caused* by them, and, frankly, mishaps involving any motor vehicle are alarmingly common. You're probably as safe in an ambulance as you are in an ice cream truck.

Here are some stats: according to data presented in 2014 by the US National Highway Traffic Safety Administration, ambulances were involved in an average of 4 500 crashes a year between 1992 and 2011. Of these, an average of 29 resulted in fatalities, while 1 500 caused injury. At the risk of descending deep into eye-glaze territory, we should add now that a little over half of both the fatal accidents and the injury-causing accidents occurred while the ambulance was in emergency use. Boiling all this down, you discover that ambulances in emergency use account, on average, for 17 fatal accidents a year. Consider that in 2011 alone there were a total of 13 947 fatal crashes in SA (or more than 38 per day) and the record for rushing ambulances doesn't look out of line. Similarly, fire trucks are routinely involved in accidents while responding to emergencies, but, data shows, they account for far fewer wrecks than do taxis, school buses or cop cars. All in all, it's a safe bet that emergency vehicles save far more lives than they cost. The real question is how many people get run over by bookmobiles while walking to the library.



How high is the elevated level of radiation you're exposed to on a plane? Do pilots have a greater cancer risk?

THERE'S NO QUESTION that flying on passenger jets exposes you to elevated levels of a lot of things, including arbitrary fees, other people's elbows, and assorted noxious and costly substances putatively classified as "snacks". Anything else you're subjected to is arguably mild in comparison. But, yes, you are hit with extra radiation up there in that fancy aluminium tube.

At ground level the atmosphere shelters us, but 10 kilometres up, levels of the rather groovy-sounding "galactic cosmic radiation" are much higher. "It comes from deep in the galaxy," explains Jeri Anderson, a health physicist at the National Institute for Occupational Safety and Health. "It's caused by the remnants of a supernova." Whoa! Shields up, Mr Sulu.

Just living your life, you're apt to soak up between 1 and 5 millisieverts (the metric measure of radiation energy absorbed by the body) each year. This comprises radiation emitted by the Earth itself, radon gas wafting around your man cave, your glow-in-the-dark watch dial, X-rays of your sprained pinkie toe, etc. Incremental exposure for airline crews is estimated at an additional 2 to 3 millisieverts.

Ideally, we'd all limit our annual exposure to 1 millisievert, though that's not easy to do absent a lead jumpsuit, and experts say levels above that aren't necessarily dangerous. Even so, there is some indication that those who work on airplanes (and presumably those who fly several times a week) face increased cancer risk. A 2014 study, for instance, found that the melanoma (skin cancer) death rate is 42 per cent higher in airline crews than in the general population, while other research has suggested a heightened breast cancer risk. But it's hard to say that radiation is the sole – or even primary – cause. For one thing, flight crews tend to suffer from disrupted circadian rhythms (a.k.a. jet lag), which can lead to hormonal imbalances that also have detrimental health effects. And anyway, that's flight crews. The rest of us probably have more to fear from overzealous pat-downs in the security line. Unless you like that sort of thing.



How many operating garbage trucks are there in the United States?

JUST ENOUGH to wake up every man jack from Kauai to Key West at 05:30 in the morning on whatever day of the week he finds himself least inclined to be woken up at 5:30 in the morning.

Yes, you say. But how many is that in, you know, numbers? Turns out nobody knows for sure.

The two top waste-disposal companies – Waste Management and Republic Services – together operate about 48 600 trucks. But, though those two giants control a hefty chunk of the market, there are a whopping 27 000 other solid-waste-disposal companies in the country, each of which you figure has to have at least one truck, and in many cases a bunch more. So even at an average of, let's say, four trucks, which may well be low, you're north of 150 000 total.

To take another tack, the National Waste & Recycling Association tallied the number of trucks nationwide at 148 000 – but that was in 2001. Industry revenue has grown 46 per cent since then, which does not necessarily mean there are now 46 per cent more trucks, but does suggest some increase. All things considered, we think a reasonable estimate would put the total number of garbage trucks somewhere within clattering-can-throwing distance of 200 000. Sweet dreams.

PM



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BREAKTHROUGH AWARDS 2015

After 11 years of celebrating the doctors and scientists, engineers and inventors, planets and popes most responsible for changing the world in our annual Breakthrough Awards, we asked ourselves: what constitutes a breakthrough? It's more than just doing something no one else has done before. (If that were the case we'd have to honour anyone who has considered voting for Trump.) It's doing something that no one else would think feasible. Like perfecting the robotic hand by building something that isn't a hand at all (see opposite). The people in the next 21 pages have propelled their industries – and our society – to new possibility. In ways that you may not immediately notice, they've improved your life. They've made Breakthroughs.

THE NEXT ROBOTIC HAND

- ▀ Different robot hands are designed, at great expense of time and money, to pick up different objects, their carefully calibrated robot fingers curling around the shape that needs picking up, be it a puppy or a jet-engine part. "There aren't many objects that can't already be gripped by a specific robotic gripper," says Bill Culley, president of **Empire Robotics**, a three-year-old company in Boston, USA. Culley and co-founder John Amend wanted to create a robot that could handle a variety of objects with speed and precision – without needing to swap out hands. So they built one that doesn't use hands at all. Their creation, the Versaball, picks up objects up to 25 cm in diameter in as little as 0,7 seconds.

HOW IT WORKS

1. In a relaxed state, Versaball's squishy composite-rubber body is filled with synthetic sand. A valve releases air into the body, softening the sides and allowing the sand to flow.
2. The ball is lowered on to the object, conforming to its shape.
3. The valve pulls the air out
4. The valve pushes air back into the ball's body, loosening the sand and releasing the object.

of the ball, jamming the granular material together and hardening the ball's body. The ball keeps hold of the object for up to five minutes through friction from pinching, vacuum suction, or simple entrapment.

The valve pushes air back into the ball's body, loosening the sand and releasing the object.

A much faster means of 3D printing

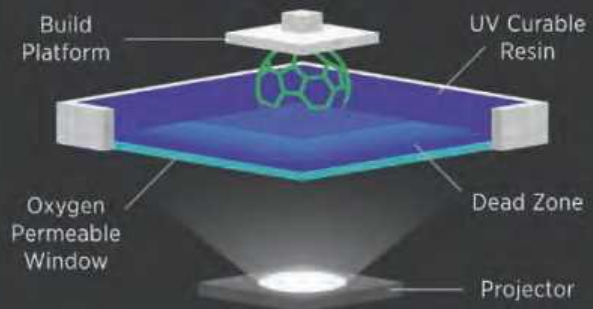
Redefining on-demand production was nice, but 3D printing sure can be slow. At least it used to be.

For all that it allows us to do, 3D printing has a major limitation: it's painfully slow. The current machines work by additive manufacturing. Like a hot-glue gun, the printer laboriously heats, drips and dries plastic strands, depositing layer upon layer as it slowly builds each object. Printing a small plastic ball can take hours, and close inspection reveals the rough and relatively fragile process that created it. That's what we would be stuck with if it weren't for the film work of Arnold Schwarzenegger. A group of chemists and physicists led by Joseph DeSimone at the University of North Carolina has completely reimagined 3D printing after being inspired by Arnie's *Terminator 2* nemesis, the liquid-metal-based T-1000.

Their company, **Carbon3D**, developed a technology called Continuous Liquid Interface Production (CLIP) that uses photo-sensitive resin that hardens when exposed to light and liquefies when exposed to oxygen. First the printer arm is dipped into a vat of resin. As the arm slowly lifts, the required shape is projected up through a window at the bottom of the vat. Oxygen is pumped in at specific times and at precise levels to inhibit and control the curing process. When the part clears the resin, all that remains is for it to be cut from



Continuous Liquid Interface Production



the printer arm and rinsed of thermoplastic residue. Like traditional 3D printing, CLIP is mesmerising to watch. It's also 25 to a hundred times faster.

Carbon3D claims the CLIP process works on a wide range of polymers with different characteristics, from spongy objects to extremely hard solids. It has created burn-resistant substances and is experimenting with embedding particulates, such as ceramics, to produce even more robust materials. The only bad news is that Carbon3D printers won't be available anytime soon for consumers. But the company does envision its printers in speciality stores, where you'll be able to print on demand – and not have to take a week off work while you wait. – DAN DUBNO



Self-steering bullets

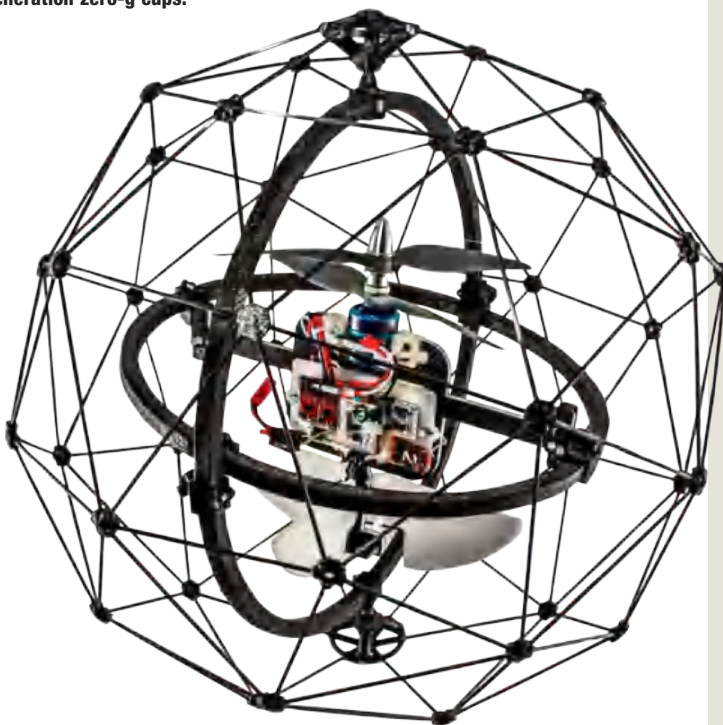
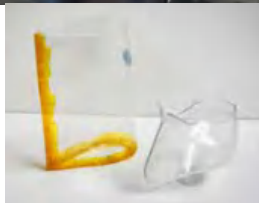
Announced earlier this year, **DARPA's** .50-calibre rounds are fitted with optical sensors that allow them to automatically change trajectory in midair. Not great news for bad guys.

PHOTOGRAPH BY JEFFREY PETERS



Left: The Expedition 30 crew drinks tea from the first-generation zero-g cup in 2012. Below left: The first- and second-generation zero-g cups.

SPACE COFFEE



A DISASTER-RECOVERY DRONE THAT CAN TAKE A BEATING

Contrary to images of astronauts casually floating around with big ol' smiles, we live and work in a dangerous, high-stress environment. When we complete a task, such as snagging the first commercial unmanned cargo spacecraft with a robotic arm or performing a delicate experiment with a virulent strain of Salmonella, we might want to discuss it later over a cup of coffee. But that experience isn't the same when you're sucking from a bag through a straw, the current solution. It works fine, but does not provide that connection between humans.

On Earth, when a straw is submerged in a cup, the liquid is drawn partway up into the straw. This is known as capillary rise and is driven by surface tension and the pressure difference caused by a curved meniscus. A straw's geometry can force the liquid to rise to the very top of the straw where it stops as if waiting for a pair of lips to come by for a sip. In the weightlessness of orbit, an open channel defined by two walls separated by a small angle essentially makes a straw. If the wall angle continuously decreases from the cup bottom to the rim, culminating in a tight angle mathematically known as a cusp, an imbalance in capillary forces moves the fluid from the bottom to the top. And as with a straw, once the fluid reaches the cusp, it stops and waits.



Pettit is a NASA astronaut and the coinventor of the cup (with physicist Mark Weislogel of Portland State University in Oregon). The cup is specially designed to allow astronauts to have a more realistic drinking experience in space. Six cups were delivered to the International Space Station in April.

In this new zero-g cup (adapted from a much simpler first-generation design) there are no straight lines. This model has a spheroidal bulk region that morphs into an interior corner, which then tapers to a cusp at the lip of the cup. A capillary gradient drives the liquid towards the lip of the cup. In operation, you don't tip the cup towards your face. You merely make a connection by touching the cusp to your lips, as capillary forces automatically push the coffee into your mouth.

In 400 years nobody will remember who invented this cup. But perhaps some future explorer will one day propose a toast on behalf of its inventors. — DON PETTIT

There are a few things you can use drones to do:

1. Spy on your enemies.
2. Spy on your friends.
3. Deliver very light items over short distances.
4. Save someone's life.

It's that last one that led Adrien Briod and Patrick Thévoz, then graduate students at the École Polytechnique Fédérale de Lausanne in Switzerland, to create the Gimball. Inspired by the failings of search-and-rescue robots at Fukushima, which often encountered impassable, debris-clogged hallways, and traditional drones, which can be knocked down by the slightest impact, the Gimball is a drone surrounded by a carbon-fibre cage that protects the twin propellers from hazards. It's attached by a three-axis

gimbal system, so if the drone does run into something, the cage absorbs the impact. The drone itself remains stable. With an on-board hi-def camera capable of live streaming and recording and an ability to withstand collisions of up to 16 kilometres per hour, the Gimball can go almost anywhere. Even if people can't.

Earlier this year their company, **Flyability**, won the UAE Drones for Good competition in Dubai and the million-dollar purse that comes with it. "The Gimball is the first drone that has a completely different field of application and does completely new things that people don't know about, and that opens a lot of opportunities when you see it," Thévoz says. Governments should be able to order the first Gimballs by the end of the year.





— When only a couple of people out of a hundred respond to a cancer drug, that drug is often shelved as a failure.

But what if you're one of those two people?

By KIRA PEIKOFF

Illustration by MATT HUYNH



AFTER A CANCER PATIENT loses the battle, when the funeral has ended and the mourners have returned home, the cancer remains. It doesn't go where the body goes, to the funeral home or the crematorium. The hospital doesn't throw

it away. Usually a pathologist freezes a piece of a tumour, or bathes it in an embalming fluid called formalin and sends it out to be fixed in a paraffin block. Then he seals it in a clear biohazard bag, puts it on dry ice, and adds it to a stockpile of other samples, their identities stripped to random sequences of numbers and letters, all awaiting a journey to a bio-repository, a tissue bank for samples such as these. There the cancer will wait among thousands of other samples, until a doctor somewhere thinks of a reason to want it.

These warehouses are catalogues of the difficulties inherent in treating the disease oncologist Siddhartha Mukherjee famously called the emperor of all maladies: of the hundreds of drugs that move into

development annually to treat cancer, only a few are safe and effective enough to receive Food and Drug Administration approval. Despite advances in chemotherapy, proton therapy, and immunotherapy, techniques that employ drugs, radiation and the immune system, respectively, to shrink tumours, more than 585 000 people succumb to the disease every year. Their tumours, fresh, frozen or fixed in wax, build up in the tissue bank.

Oncologist-researchers, the united human front line against cancer, are accustomed to disappointment. They tend to be driven by the conviction that cancer can be beaten, in spite of the massive trove of evidence to the contrary. David Solit, an athletic 46-year-old with eyes as blue as a work shirt, is a perfect example. In medical school he chose oncology because his aunt had died of breast cancer. "I wanted to find better treatments for people who had incurable tumours," he says. He is not intimidated by the word incurable.

Back in 2010, Solit was in a meeting on the fourth floor of the Kimmel Centre, a treatment space for prostate, bladder and related cancers at Memorial Sloan Kettering Cancer Centre in New York City, where he works. In a windowless conference space, some 15 doctors, researchers and nurses sat around a U-shaped table in white coats, discussing the hospital's clinical drug trials. The meeting was a weekly status update for a drug called everolimus, which blocks a protein called mTOR that makes cells grow and divide. Forty-five bladder cancer patients had received everolimus. Nearly all of them – 43 – had no response at all.

The doctors considered scrapping the drug entirely. But then Solit asked a critical question: what happened to the other two? One patient had had a partial response. But the other had gone into complete remission. She had remained cancer-free for two years. "I knew from that one patient that enough of the drug got into her tumour for it to work," Solit says. "For me, that meant it was a good drug. We just didn't know who to give it to."

The patient was exceptional, and Solit intended to find out why.



cancer is not a single disease. In concept it is the growth of abnormal cells that spread around the body, overwhelming its systems like a weed in a garden. But what kind of weed it is and how fast it spreads are different in each case. Pancreatic cancer will kill you much faster, on average, than

breast cancer. A type of lung cancer that is caused by a mutation in the gene for a protein called KRAS is far more lethal than the same type of lung cancer caused by a mutation in the gene for EGFR. What makes cancer so difficult to beat is that the mechanisms are unique to each person and, indeed, to each cancer. A drug that causes remission in one case may do nothing in another.

Because a tumour's genetic background can direct potential treatments, researchers have been keen to genetically map tumours since the technology became possible in 2000. If oncologists could map a tumour's entire genome, goes the theory, they could compare it with a reference sequence made up of normal DNA. Mismatches might explain what caused



National Cancer Institute oncologist Barbara Conley (left) and Memorial Sloan Kettering medical oncologist David Solit (right) are two researchers making progress towards a cure for cancer. Both have also lost family members to the disease.

the tumour to grow. Correcting the mismatch could cure the cancer.

And so Solit will be the first to tell you that discovering the genetic target of the drug everolimus was partly due to luck. In 2010, whole-genome sequencing, the technique that would eventually allow Solit to sequence the tumour from the woman who had the exceptional response, was on the cusp of availability. At first he and more than a dozen of his colleagues tried to study the tumour "the old-fashioned way" – one gene at a time. Tumour cells have approximately twenty thousand genes, the same as in a normal human cell, which made this an inefficient, and not particularly promising, undertaking.

Then came the luck: Illumina, a San Diego-based biotech company, engineered a digital DNA sequencing machine, a sleek tabletop lab-computer complex that could analyse the sequence of bases – A, G, C, and T – in millions of fragments of DNA, then reconstruct the fragments to show a tumour's entire raw genetic code. The cost of the experiment Solit dreamed of doing, sequencing the full genome, dropped from tens of millions of rand to just R250 000. (As computer power accelerates, the cost continues to drop: the same experiment today would cost only R25 000.)

With the lower-cost option available, the hospital contracted

the sequencing out to Illumina, and, when the results returned, Solit and his colleagues began to sort through more than three billion base pairs' worth of data to figure out which one was relevant to the cancer. This is like trying to find a single misspelling in a book with six billion letters. It took six computational biologists five months to solve the puzzle. The exceptional patient had a mutation in two genes, called TSC1 and NF2. Through a complex metabolic pathway, the mutations allowed mTOR, the protein affected by everolimus, to run wild, creating new, malignant cells all over. There it was – sense made out of a blind mess of human suffering. A protein that told cells to grow and divide like crazy. The drug that shut it off.

"It was incredibly exciting," says Solit.

After undergoing the peer-review process, Solit's finding appeared in the journal *Science* in 2012. It wasn't exactly the cure for cancer, but it did point in the cure's direction, and other leaders in oncology noticed. At the National Cancer Institute, a part of the National Institutes of Health in Rockville, Maryland, oncologist and developmental therapeutics researcher Barbara Conley thought Solit's work could help her streamline testing for cancer drugs. In standard clinical trials for these types of drugs, patients are grouped according to the origin site of their cancer –

prostate, breast, liver, brain. Then, depending on how the entire group responds during the test, a drug is either abandoned by the pharmaceutical company, or it's pursued through three phases of government trials until it is finally allowed on the market. Solit's work made Conley think patients could be grouped according to genetics instead.

"It would be nice if we could predict who will respond to which drugs," Conley says from her office on the fourth floor of the steel-and-granite National Institutes of Health building. She's in her early sixties, and has short hair and a warm smile. Her manner conveys a subdued enthusiasm – the cautious hope of a doctor acquainted with tragedy. Like Solit, she has suffered personal losses from cancer: her father and all four grandparents died of it.

Soon after the Science article, Conley led the development of a new Exceptional Responders Initiative at the National Cancer Institute, which officially launched in September of last year. Today any oncologist anywhere in the country who has a patient who has responded positively to a cancer drug for at least six months can propose her case. The doctor sends an email without identifiers, but with enough details to assess whether the case is an exceptional responder, to a dedicated email address. Then a reviewing committee of doctors and scientists determines whether the patient is an exceptional responder, and the oncologist will call up one of those tissue banks and send in samples for genetic sequencing. Informaticists at the institute will comb through the data looking for mutations. Then the report will be given to researchers who assess whether the patient's drug response can be explained by his or her unique biochemistry.

Within two to five years the programme's results may start to guide treatment decisions for the rest of us, eventually revolutionising not only patient care, but also the very nature of how drugs are tested. When you can determine what's causing a patient's cancer from the outset, the old standard of assigning patients to double-blind, randomised trials with a placebo arm and a treatment arm no longer makes sense. Trials will get smaller and more efficient, with drugs tested only in patients who have the right mutations and are most likely to benefit.

"You don't want to put extra people at risk," says Conley. "So we'll see smaller trials with higher response rates... that theoretically lead to faster approvals." To that end, the NCI is co-ordinating a new cancer drug trial that just started midyear. At up to 2 400 centres across the USA, cancer patients who have eligible mutations will

be matched with one of more than 40 targeted drugs. As doctors have long suspected, the cure for cancer will actually be cures for cancer. And we're about to find a lot more of them.

B

ack at Sloan Kettering the personalised approach to cancer treatment is already under way. In May of 2014, philanthropists Marie-Josée and Henry Kravis donated R1,3 billion so the hospital could open a

Centre for Molecular Oncology under Solit's direction. By July the centre had rolled out the cutting-edge MSK-IMPACT test, a screening tool that looks for mutations in 341 genes known to be associated with cancer. Since the IMPACT test was introduced, more than 5 000 patients have been screened, at a rate of 500 per month, which

HOW TO DETECT CANCER: AN ALTERNATIVE GUIDE

The earlier a cancer is found, the better your chance of beating it. That's why researchers are constantly looking for new, better ways to detect the disease, many of which are unexpected. – SARAH Z. WEXLER



SCORPION VENOM

When removing brain tumours, surgeons want to remove as little healthy tissue as possible. To help discern the difference, Cedars-Sinai Medical Centre in Los Angeles is testing "tumour paint" made from scorpion venom. It's injected into the patient's vein and makes the brain tumour glow under near-infrared light.



SOUND WAVES

Researchers at Carnegie-Mellon University and Penn State University use sound waves to check cells, since healthy white blood cells and malignant cancer cells deflect the waves differently. Tests on human blood samples have been promising, and scientists are hoping for FDA approval.



BACTERIA

Bioengineers from MIT and the University of California, San Diego, engineered bacteria to produce an enzyme, LacZ, when it encountered tumours. They fed the bacteria to mice, then injected them with a molecule that makes the mice's urine glow if it binds with LacZ. Trials detected liver tumours as small as one cubic millimetre.



BREATH

The Nanoscale Artificial Nose, co-developed by researchers at the University of Colorado Cancer Centre, analyses volatile organic compounds in the breath. After patients exhaled into the device, the NaNose was 85 per cent accurate in distinguishing patients with early lung cancer from those with benign lung problems.



DOGS

In a 2014 study at the Italian Ministry of Defence Military Veterinary Centre, two German shepherds trained in explosives detection were taught to find volatile organic compounds tied to prostate cancer. The dogs sniffed the urine of men with and without prostate cancer and were able to detect it correctly more than 98 per cent of the time.



GOOGLE X

Google's experimental division is working on an ingestible pill made of specialised magnetic nanoparticles that can bind to cancerous cells. The infused cells could then be tracked and counted by a wearable device, helping doctors see where and how quickly the cancer is spreading.

will increase to a thousand a month by the end of this year. If the test finds a known, treatable mutation, the patient is eligible for basket studies, new clinical trials in which patients are enrolled and treated based on their tumour's genetic profile rather than on where it is.

In Solit's windowed corner office overlooking East 69th Street, the doctor spins in his desk chair to face his computer, where he brings up two PET scans for a late-stage metastatic breast cancer patient who was treated in a basket trial after receiving the IMPACT test. "We've seen some dramatic responses," he says. He gestures to the first image, a pretreatment scan of the patient's body that looks like a target from a shooting range, lit up with between 50 and a hundred red dots, all of them tumours. The second scan shows the same patient after eight weeks in a trial for a drug that inhibits some of the functions of a protein that was malfunctioning to cause her cancer. The second scan is completely clear.

Rita Porterfield, 65, is another patient whose life has been extended thanks to the IMPACT test. After 15 years of suffering from intractable bone pain, Porterfield was diagnosed with a rare disease called Erdheim-Chester, for which there are no FDA-approved treatments. By 2013, she was so ill that she couldn't walk. Her doctor gave her only a few months to live.

But genomic profiling showed that she had a mutation in a gene called BRAF, which leads to the production of an abnormal protein. A drug that inhibits this abnormal protein, called vemurafenib, already existed for melanoma patients, though it was not approved for Erdheim-Chester. By enrolling in a basket trial, Porterfield received free access to the drug, which otherwise costs nearly R200 000 per month.

"I was on the pills for three days when I told my husband, something's happened, something feels different," she says. "All of a sudden I started to get stronger and a little better at balance." Six months later and 36 kilograms lighter, she was running around with her grandchildren, and playing bells and piano in her church choir. "I have a life again," she says. "It's a fun life now."

Even as experiences like Porterfield's hint at the end of cancer as we know it, they reveal another,

more insidious barrier to care: genomic profiling may revolutionise the way we treat cancer, but our lumbering medical infrastructure might take a while to catch up. A drug may be FDA-approved, but insurance can still refuse to pay for it unless it's a "standard of care" in a given cancer. Genomic screening tests may not be covered for the same reason.

"Maybe the money's not coming from the traditional insurance system," Solit says. "We then have to rely on the generosity of people who believe this is making a difference." Sloan Kettering plans to pay to screen the majority of advanced cancer patients who walk through its doors – some 10 000 annually – out of its own funds.

Every year Solit participates in one of the annual indoor cycling events for the cancer charity Cycle for Survival, which has raised R1 billion for research and treatment so far. The cause is personal for him and not just because of his patients or his aunt. In March of 2014, Solit's sister-in-law died of breast cancer at 43. For a cancer doctor, this is a particularly egregious insult: the very disease you've dedicated a lifetime to studying lashing out at your own family. But this is how cancer works – a tiny defect that is with you from the beginning, like a ridge in a fingernail, that spreads to crash the entire system. You can't protect anyone from it.

In his office, Solit looks at a picture of himself and his wife pedalling at last year's Cycle for Survival fundraiser. "Nobody wants to die at any age," he says. "But I do think that we can do better." After all, the ultimate goal of cancer research isn't immortality – we're all going to die. What Solit wants is what all doctors want: to give his patients the fullest life they can have, for as long as they have left.

But figuring out how to do this takes time, and a weed has no concern for human timetables. A weed cares only about expanding its territory. While Solit searches his patients for the underlying defects that caused the weed to grow in the first place, the weed germinates somewhere else. It proliferates. It overwhelms. During cancer's millennia-long history, it has always gone this way. Except when it hasn't. And those few, wonderful times just may save us yet.



A FLAT-PLANE ENGINE IN AN AFFORDABLE CAR

Flat-plane crankshafts are the stuff of exotics and racecars. Traditional V8s are smoother and naturally well balanced, but flat-planes alternate ignition between the cylinder banks, allowing better breathing at high r/min. So while traditional 90-degree V8s issue a throaty lope at idle and a deep bellow at higher r/min, flat-plane (180-degree) cranks hum impatiently at low r/min and bark out a staccato banshee scream at redline. If you've heard a Ferrari V8, that's the flat-plane howl, the sound of refinement sacrificed for outright power. And now it's the sound of the Mustang, as the new generation of Shelby GT350s gets the first flat-plane engine in Ford history. It's a barbarian – a 5,2-litre V8 that redlines at 8 250 r/min and makes 392 kW without resorting to turbos or a supercharger. It won't be as silky as the GT's 5,0-litre V8, but that's the point.



Live translation over the phone

Microsoft's new Skype Translator translates video calls into six different languages in real time. As users speak, a Skype Translator bot recognises and corrects the speech before translating verbally and on-screen. All for free on Windows 8 and 10 devices.

The monitors of the sea

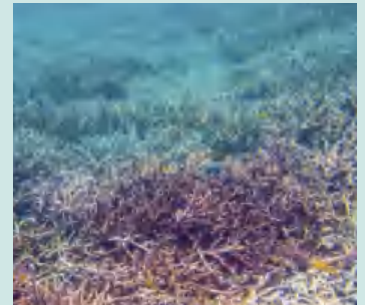
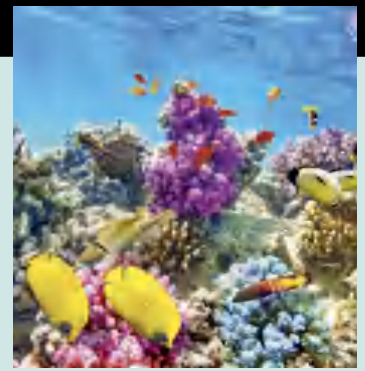
How two guys in Montana are changing the way we study oceans.

You know Montana. Big state. Beautiful. Also: completely landlocked. More than 600 kilometres from salt water, and that's if you're heading in the right direction. Despite that, a company in Missoula called **Sunburst Sensors**, founded by chemist Mike DeGrandpre and mechanical engineer James Beck, is somehow at the forefront of oceanic research. It took some ingenuity – the two constantly found themselves asking friends to bring back water samples whenever vacations took them to either coast – but two years ago Sunburst entered two X Prize Foundation challenges (which were originally announced at the POPULAR MECHANICS Breakthrough Awards ceremony in 2013). One was to create a highly accurate pH sensor that could withstand a depth of 3 000 metres. The other was to make a shallow-water sensor that costs less than \$1 000 (about R13 000) and measures pH more accurately than what's already available. Sunburst won both. And R20 million.

In the last 115 years ocean surface temperatures rose almost one degree, while pH levels decreased by 0,1 per cent. Those seemingly small numbers have big implications. Of all the carbon humans spew into the atmosphere, about a third is absorbed by the oceans, resulting in this acidification. Today our oceans are roughly 30 per cent more acidic than before the Industrial Revolution. This could be devastating to coral reefs, bivalves and other marine life – pretty much everything that lives in the sea.

To create their winning entries, Sunburst (which has been making commercial freshwater and marine sensors since 1999) modified its preexisting Submersible Autonomous Moored Instrument (SAMI) pH

Coral is sensitive to changes in ocean temperature and chemistry, such as heightened carbon levels.



sensor. A new titanium housing containing all of its parts made the SAMI tough enough for the deep-water challenge. Replacing pricey components and revamping sensor functions resulted in a SAMI more accurate, efficient, and less expensive than comparable sensors. With these new tools, more scientists will be able to study pH levels, and at greater depths, than ever before.



The shutterbug space probe

Nine years and 5 billion kilometres after launching, NASA's New Horizons has changed the way we see our universe. BY CHRIS HADFIELD



Hadfield, a retired astronaut, was the first Canadian to walk in space. His 2013 rendition of David Bowie's "Space Oddity", filmed aboard the International Space Station, has received more than 26 million YouTube views. He is also the author of the book *An Astronaut's Guide to Life on Earth*.

When the New Horizons probe launched from Cape Canaveral back in 2006, its three-stage rocket pushed it to more than 58 000 km/h, making it the speediest ship ever built. It went past the Moon in just nine hours. Even after coasting in the Sun's gravity for nine years, it was still clocking over 51 000 km/h this July when it finally swept past Pluto, three billion kilometres

away. That's 14 kilometres per second.

In 2013, as I orbited Earth for five months on the International Space Station – at a mere 8 kilometres per second – I often thought of New Horizons racing across our solar system like some hypersonic go-kart. And every time I took a picture of our world, I imagined the problems the probe would eventually have photographing Pluto.

The ISS has several windows facing straight down, like a glass-bottomed boat. I would hook my toes around a hand-rail to stabilise my weightless body, hold the digital camera and lens gently in my hands, carefully pivot while focusing, and smoothly push the shutter. Then I'd check the display to see how it looked.

Even with my extra care, the pictures would often be blurred or dark. I hadn't tracked the ground quite right, or my heart-beat had moved my floating arm and hand at just the wrong moment. Either way, I could try again the next time I came around Earth, 92 minutes later.

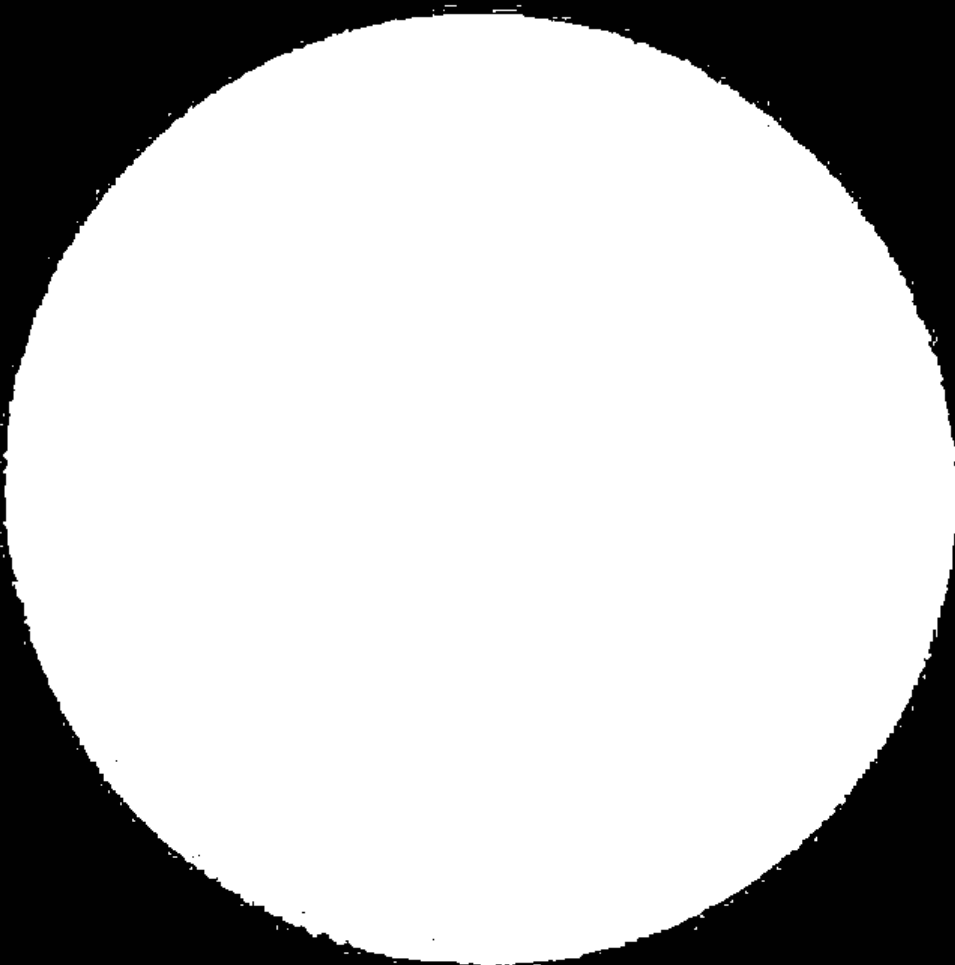
It made me dread what it was going to be like for New Horizons out by Pluto, and for her engineers sweating it out back on Earth. There would be only one try, with no do-over. Every command took more than four hours to get there, so it all had to be predicted and programmed. And the sensors were bolted directly to the probe, so the whole contraption had to turn as Pluto passed, like a photographer in a body cast.

Yet, somehow, they got it spectacularly right. As each clear new image arrived, I was astounded – like a kid watching

fireworks. The kilometre-high mountains of solid ice. The huge, flowing nitrogen-methane glaciers. The asteroid scars. The whisper-thin atmosphere being slowly blown out to space by the solar wind. Even as a veteran of three spaceflights, it amazed me.

And still New Horizons races on into the eternal night, on the hunt for even farther planetoids. Our distant emissary, patiently staring, making discoveries at a speed we can barely imagine.

Pluto, 14 August 2015.





PROSTHESES CONTROLLED BY YOUR MIND

Easton LaChappelle revolted against the staggering cost of prostheses by designing an inexpensive model in his bedroom. Then he did something even more impressive: he gave away the plans for free.

Like all good breakthroughs (or at least the one on page 28), this one goes back to the cinematic oeuvre of Arnold Schwarzenegger: "My parents definitely let me watch *Terminator* too young," says 19-year-old Easton LaChappelle.

At 14, having experimented with electronics since primary school, the Colorado native became fixated on building a robotic arm. But his aim was far more altruistic than creating a cybernetic army. After an encounter at a local science fair with a seven year old whose prosthetic arm had cost R1 million, he vowed to invent a prosthesis that was as technologically advanced as it was reasonably priced. Using fishing wire, Legos, electrical tubing, and toy-plane motors, LaChappelle assembled a prototype in his bedroom for less than R6 000. Subsequent models were made with a 3D printer and incorporated an EEG headset to read brain waves. They earned him a trip to the White House to meet President Obama, a NASA internship, a TED Talk, and, ultimately, startup capital from multimillionaire motivational speaker Tony Robbins. With that

financing, LaChappelle co-founded **Unlimited Tomorrow** in 2014. In addition to further evolving the RoboArm, as it's now called, the company is developing an exoskeleton for paraplegics as well as a revolutionary non-joystick control system for existing robotic platforms.

Since LaChappelle began his work, the need for affordable prostheses has grown only more urgent. According to a 2010 study by the US Department of Veteran Affairs, a prosthesis for a soldier who has lost an upper limb in the Iraq and Afghanistan conflicts will cost a lifetime minimum of R75 million. So rather than wait a few years for FDA approval and its attendant fortune, LaChappelle announced at January's Consumer Electronics Show that Unlimited Tomorrow would make the first version of the Robo-Arm design open-source via its website. Completely free.

"It just got to the point where we wanted to get it to the people who really need to use it," he says. "We are focused on improving human life." The money can always come later.

Concrete that can withstand a bomb blast

In the predawn darkness in April 2013, the attackers snipped telephone cables near Pacific Gas and Electric's Metcalf transmission substation outside San Jose, California. They systematically shot and knocked out 17 of the transformers that power Silicon Valley. Within half an hour they were gone, leaving R200 million of damage behind them.

Although few Americans know about this attack, it exposed the vulnerability of the electrical grid. In response, the Federal Energy Regulatory Commission demanded that utilities protect their substations. But it didn't say how. This year Oregon-based **High Impact Technology** (HIT) announced a solution: 10 cm concrete walls that can withstand bomb blasts, bullets, 200 km/h winds, and fires burning at 1 200 degrees. That's more than a slight improvement on the existing technology. "When most of the grid was built, in the 30s, 40s, 50s and 60s, international terrorism or domestic terrorism wasn't part of the conversation," says HIT director of operations Russ Monk.

The new walls are reinforced with composite rebar that's twice as strong as steel, which forms a skeleton underneath a layer of high-grade reinforced concrete. An external rubberlike coating binds to the face of the concrete, allowing the walls to absorb cracks from the impact of blasts and bullets. Whereas normally it takes 20 cm of solid concrete to stop a bullet, HIT's walls do it with half of that. And 2 cm of those is extra, added to handle wind load.

AN EVEN FASTER TESLA

Tesla's P85D was already a 515 kW particle beam of a sedan, with an Insane Mode that unlocked 3,1-second 0-to-100 km/h sprints. So Tesla, naturally, gave it more power. The new Ludicrous speed provides 568 kW, 0 – 100 in 2,8 seconds, and a 10,9-second quarter-mile.

Thus making the Model S P85D the only ten-second sedan, and Tesla the only company with the sense of humour to reference a Mel Brooks space comedy.





Dave Masten in his bare-bones hangar at the Mojave Air and Space Port.



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— • Deep in the California desert, an unknown entrepreneur is competing against famous billionaires for a chance to build the next great spacecraft. He's outmanned and out-financed. And he just might pull it off.

By JOE PAPPALARDO

Photographs by KEVIN COOLEY



Dave Masten stares at his computer screen, finger poised over the mouse button. He knows that opening this email, sent by the Defence Advanced Research Projects Agency, the Pentagon's advanced technology lab, will change his life. One way or the other.

This email is the fulcrum of his future. It is either an acceptance letter or a rejection letter for his company's proposal to build what DARPA calls XS-1: an experimental unmanned space plane that can fly ten times in ten days, reaching a speed of Mach 10-plus and lifting payloads greater than 1 300 kilograms to orbit, at a cost of no more than \$5 million (R66 million) per flight. Being accepted as one of the three competing contractors represents the best shot that Dave Masten – perennial underdog, Silicon Valley refugee, scrappy space-industry entrepreneur – will have to build a working spacecraft. It would mean an immediate infusion of R40 million, with more coming the next year. The final contract could be worth as much as R2 billion.

Being rejected would mean the status quo: toiling in the desert in continued obscurity, with a thin profit margin and languishing dreams of building orbital spacecraft. It would also be the loss of a rare opportunity. Historically, government launch programmes favoured – if not outright mandated – spacecraft that could return to Earth on a runway or under parachutes. But Masten's rockets use a vertical-takeoff, vertical-landing design – no runway or parachute required. The XS-1 programme allowed for this design. There was no

telling if the government would continue the allowance for future launch programmes. This could be his only chance.

One email, two roads. One leading straight to space.

Double-click.

Masten reads slowly and deliberately. Then he turns to the engineers gathered near his desk, nonchalant, and says: "I've got some good news and bad news. The good news is we've been selected for XS-1. The bad news is we've been selected for XS-1."



The Upper Mojave Desert is like some terrifying postapocalyptic dream: abandoned gas stations covered with hieroglyphic graffiti, battered highways streaked with mouldering road-kill. Mountains. Heat. And that endless, empty blue sky.

Except it's not entirely empty. The western United States is home to the R-2508 Complex, the epicentre of American military aircraft training. F-16 Fighting Falcons, F/A-18 Hornets, and F-35 Lightning IIs from local air bases and training centres tear through 50 000 square kilometres of protected airspace, just as Chuck Yeager did when he broke the sound barrier here 68 years ago.

Though closed to passenger planes and private flyers, the air-

space is open to tenants of the nearby Mojave Air and Space Port, which was certified as the country's first commercial spaceport in 2004. Masten moved in that same year, after Cisco Systems bought the startup where he was working as a software engineer. He had his choice of several empty buildings. He picked a beat-to-hell former Marine Corps barracks from the 1940s with a leaky roof and crawling with black widow spiders. It was perfect. The six-metre ceilings were plenty high enough for the launch vehicles he was designing – just him and the three guys working for him. Even better, he secured several launchpads from which to fly his fleet.

For the next few years the only people who knew Masten Space Systems existed were a handful of industry insiders and fellow spaceport tenants – which included some of the biggest names in the private space business, like industry forefather Scaled Composites and Richard Branson's Virgin Galactic and Paul Allen's Vulcan Stratolaunch Systems, their massive hangars housing pieces of manufacturing equipment that cost more than the entire net worth of MSS. But then in 2009 the company won a R13 million NASA-sponsored lunar lander competition, and suddenly it had a little recognition and a

lot of business. Its rockets were regularly hired out by NASA, the Department of Defence, and top universities for high-altitude experiments and research.

MSS gained even more respect after being selected as one of the three XS-1 competitors. The other two: mega defence supplier Northrop Grumman and Boeing. And not only them. Boeing was working in partnership with Blue Origin, the aerospace company belonging to Jeff Bezos, while Northrop Grumman was working with Scaled Composites and Virgin Galactic. MSS, meanwhile, had teamed with another tiny Mojave firm, XCOR Aerospace. So to build his company's first spacecraft, all Dave Masten had to do was beat out the most advanced, well-financed aerospace firms in the world. And he had just thirteen months before the next round of judging.



This past August, just a couple weeks before the announcement of those results, Masten recounts the day of that fateful email over breakfast at the Voyager Restaurant, on the ground floor of the spaceport's administrative building. It's a greasy spoon on the spaceport grounds that doubles as a shrine to the 72-year-old founder of Scaled Composites, Burt Rutan, and is named after his plane, Voyager, which in 1986 became the first aircraft to circumnavigate the globe without stopping or refuelling. A map of this quest covers one wall.

The commercial space industry is dominated by outsize ambition: Rutan, Branson, Allen, Bezos, Elon Musk. Each considers himself to be a true avatar of the future of spaceflight. Masten is different. He's from Cleveland, for one thing. He doesn't evangelise. He doesn't want to be bothered with micromanagement and self-aggrandisement. His title at the company he founded is chief technology officer, not chief executive officer. He's plain-spoken. Not antagonistic or antisocial. He'd just rather be working than giving interviews is all. He eats his omelette quickly and then it's right back to the garage.

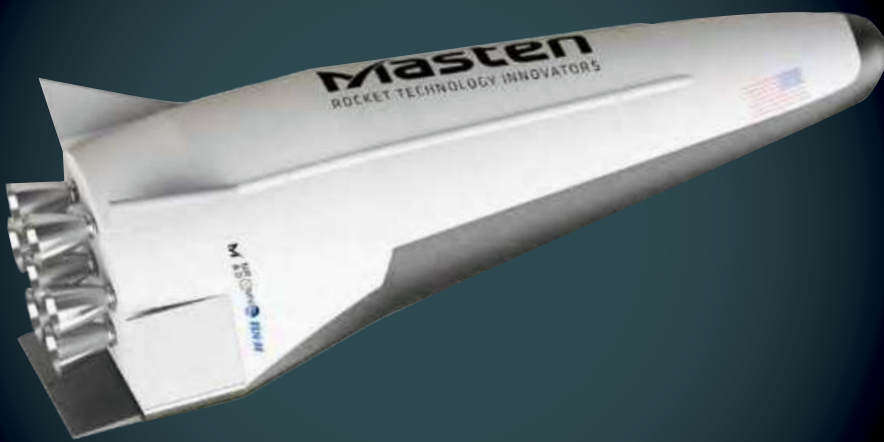
It is only slightly less ramshackle than when Masten

took it over. The roof still leaks, and you still have to watch out for black widows. Tool chests line the walls, which are bare except for company banners, a whiteboard filled with equations, and an American flag. In the middle of the hangar is a Masten rocket called the Xaero-B, standing on four spindly metal legs with two large spherical tanks stacked atop each other. One tank is meant for isopropyl alcohol fuel, the other for cryogenically chilled liquid oxygen. Another ring of tanks circles its waist: canisters of helium, used for the reaction control system thrusters that help orient the vehicle. The engine at the bottom is gimbaled to give the threadbare insectoid craft the ability to steer.

Several employees attend the craft, prepping it for an upcoming experiment

rocket vehicles meant for carrying supplies, not astronauts or tourists – the spacecraft equivalent of semi-trucks that might one day cart oxygen and hydrogen from the lunar surface to some Lagrange point filling station between Earth and the moon. This is why his rockets use a vertical-takeoff, vertical-landing design. “It’s the one landing method I’m aware of that applies to every solid body in the solar system,” he says. “You can’t land an airplane on the moon.”

A rendering of Masten Space Systems' vertical-takeoff, vertical-landing XS-1 space plane.



by the University of Colorado, Boulder, to prove that spacecraft can communicate with ground-based telescopes and thus help find exoplanets.

Masten’s small company and its location attract a certain kind of dedicated, badass engineer-mechanic. “I interned at Boeing in the 777 propulsion department,” says Kyle Nyberg, 26. “Good people, good company. But I got very restless sitting in an office all day. I assumed the next 40 years of my life would be spent like that, and it really freaked me out. In a small, scrappy company like Masten, the engineers are given both the pleasure and frustration of fabricating their designs with their own hands. It’s very uncommon.”

He and his coworkers wear T-shirts that say Moon First, a core company belief about the best destination for NASA’s next mission and another way in which Dave Masten differs from the industry’s famous billionaires. While most of them dream the big dream of open access to space and the fantastical future that comes with it – intergalactic vacations and Mars colonies and all that – he advocates more utilitarian aims.

“They started off trying to build a 747,” he says of his contemporaries, “but we haven’t even figured out how to fly yet.”

Masten’s primary focus has always been devising

Vertical takeoff and vertical landing are also key to reusability. Some of Masten’s rockets have flown hundreds of times, and they can be readied for relaunch in less than a day. The XS-1 competition goal of ten flights in ten days? That’s approaching routine for Masten. The other two teams haven’t done it once.



A couple weeks later DARPA would announce that all three teams were advancing to

Phase 1B of the XS-1 competition, for which they’d each receive an additional \$6 million. Phase 1 focused on design and infrastructure plans, i.e. prove you can do it. Phase 1B is devoted to flight tests, compiling related data, and further design work on the aeroshell – prove how you’ll do it. The results of Phase 1B are expected next summer, with

the first XS-1 orbital mission to take place as early as 2018.

Whatever the outcome, Masten’s simply making it this far has vast implications for the private space industry. “It changes the game,” says Hannah Kerner, a former NASA engineer and the executive director of the Space Frontier Foundation. “DARPA has not only opened up the playing field for commercial space companies but has recognised these newer, agile companies as serious players.”

The irony is that should Dave Masten pull off the upset he would likely no longer be able to stay so agile. He would have to scale up to meet the payload and performance requirements. He would have to hire more staff. He would have to abandon the slow-and-steady strategy. He would no longer be the underdog.

“The XS-1 is maybe a bigger step than I wanted to take,” he says, “but it’s a step on the path. We are going to orbit.”

Even without the XS-1 contract, MSS can’t really claim also-ran status any longer. In August it opened an office at Cape Canaveral, the Florida space centre that is reinventing itself as a crucial hub for commercial launch companies. There MSS resides in the same strip-mall business park as SpaceX, not far from one of the key gates into Kennedy Space Centre.

Still, Masten Space Systems is undermanned and underfunded, a ragtag bunch out in the desert, drilling and hammering and soldering in their small badlands garage down the block from the rich folk. They’re still the ones to root for.

“I think we can be competitive,” is all Masten would say about his chances in XS-1. It would do him no good to overpromise anything – something other space-industry upstarts have a habit of doing. Some great men speak greatly, and it is that ability that helps them be great. Masten is the other kind of great. Quiet. Hard-working. Understated. But, in his own quiet way, as insatiable in his desire for progress as the rest of them.

In the garage a sonic boom, courtesy of a military jet high above the desert, cracks like an overhead cannon shot. Dust sifts into the air and the warehouse’s metal doors rattle. Masten doesn’t even flinch.



The new way to watch sport

On 23 June, Miami's Giancarlo Stanton hit a massive 145 m two-run homer, his 26th of the season. But it wasn't the distance (he's hit longer) or the tally (it certainly wasn't his last) that had fans talking and the front office giddy. It was the searing 190 km/h at which the ball came off his bat, one of the fastest home-run balls of the year.

With the introduction of Statcast, exit velocity is now part of the baseball vernacular, as is the ability to assign cold,

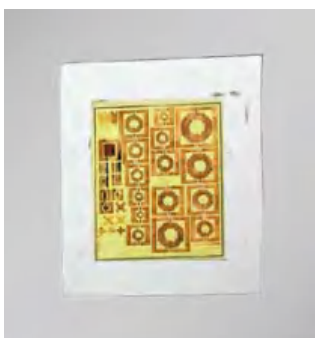
hard metrics to our amazement. This year **MLB Advanced Media** (the nimble digital arm of Major League Baseball) installed the two-pronged tracking system – a radar sensor above home plate and a set of stereoscopic cameras along the third-base line, which together collect data on the ball and the players during every play – into each of the 30 major league ballparks. All of those cameras create an impressive average of seven terabytes per game. In order to turn that information into something that

both teams and fans can understand and use, whether for recruiting or winning barroom arguments, MLB enlisted New York University mathematicians to develop advanced algorithms that crunch the numbers in real time. Now, seconds after a play, broadcast graphics can cite the rate of spin on a thrown ball (like the 2 560 rpm off the fingers of Cincinnati closer Aroldis Chapman), critique the efficiency of a base runner's path, or marvel at the launch speed of that Stanton homer.



The Pope for our time

Pope Francis is on Twitter. That would be enough. But this year, he issued a letter to the world acknowledging that global climate change is real, and that it's partially caused by humans. Then he convened a meeting of world mayors and governors to address the problem. God bless.



COMPUTER CHIPS MADE OF WOOD

Your TV, phone and Xbox are hard to get rid of, and not just for sentimental reasons. The electronic devices we use every day are powered by microchips, and those microchips contain precious or harmful elements like silicon, gold, gallium and arsenic. You don't want these things sitting in landfills, where the chemicals can leak into the ground. But right now that's exactly what many do. This issue prompted an idea from **University of Wisconsin-Madison professor Jack Ma and his team**: why not make the chips out of wood? The crucial circuits are still made of silicon or gallium arsenide, but in a quantity up to 5 000 times smaller than that of typical chips. Those circuits, about a hundred nanometres thick, are placed on a base of cellulose nanofibril – wood that has been broken down to the nanoscale, then reassembled into what is essentially a thin, durable paper. The result is a biodegradable, environmentally friendly microchip. Consumers won't be able to buy the chips directly, but Ma says that three major computer chip manufacturers could soon be making them. – JAKE CAPPUCCINO

Deanne Bell makes kids want to be engineers

It helps that they might get to interview an astronaut. BY ROBERT VRABEL

Say you've come up with a great idea. Could be a plan for a new business or a way to bolster the dwindling Asian elephant population. Who do you tell? Your mom? Your best friend? Deanne Bell told NASA.

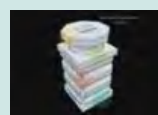
The accomplished mechanical engineer and television host (PBS's *Design Squad*, Discovery Channel's *Smash Lab*) got involved in STEM education in 2008. "I started speaking to kids about engineering careers and the diversity of things you could do as an engineer, and it kind of grew from there," she says. When Made in Space, a California-based engineering firm, announced the Zero-G Printer, a 3D printer designed to work aboard the International Space Station (the first of its kind), Bell had her epiphany. With the support of NASA and Made in Space, she started Future Engineers, an educational platform with an emphasis on inspiring a new generation of innovators. Each year the organisation holds a competition for kids to design objects that could be 3D printed and used on board the space station. Their creations are submitted to the website, futureengineers.org, which also provides instruction videos that teach kids basic scientific principles and elements of 3D design. The inaugural challenge started on 21 September 2014, the very same day the printer was launched into orbit.

The competition asks two groups of kids (broken into junior and teen categories) to create and submit

3D models of containers that would prove useful in the zero-gravity environment of the ISS. Among the hundreds of submissions were an arched food cover that keeps your dinner from flying away, a space football, and an innovative adjustable finger splint. Bell believes that no entry is too intricate (a fruit fly habitat with its own oxygen generator). Or too simple (a bobby pin). "We encourage all students to dive in," she says. Four finalists are selected to answer questions from astronauts and ISS personnel regarding their designs. One of last year's winners will be taken to a NASA facility to watch his design (a multitool) be printed live in space. For a look at this year's entries, including a cage that keeps nail clippings from puncturing any of the important tubes in the space station, head to future-engineers.org.



A FEW OF THIS YEAR'S ENTRIES



Collapsible container (teen division): Expand or compress to fit different contents. The screw-on lid has a built-in handle.



Cookie dispenser (junior): Stack the cookies over the plunger in the centre tube, put the cap on for freshness, dispense when hungry.



Zero-G fluid cleaner (teen): A device to process urine into drinking water. (Wisely leaves the actual filtration process up to NASA.)



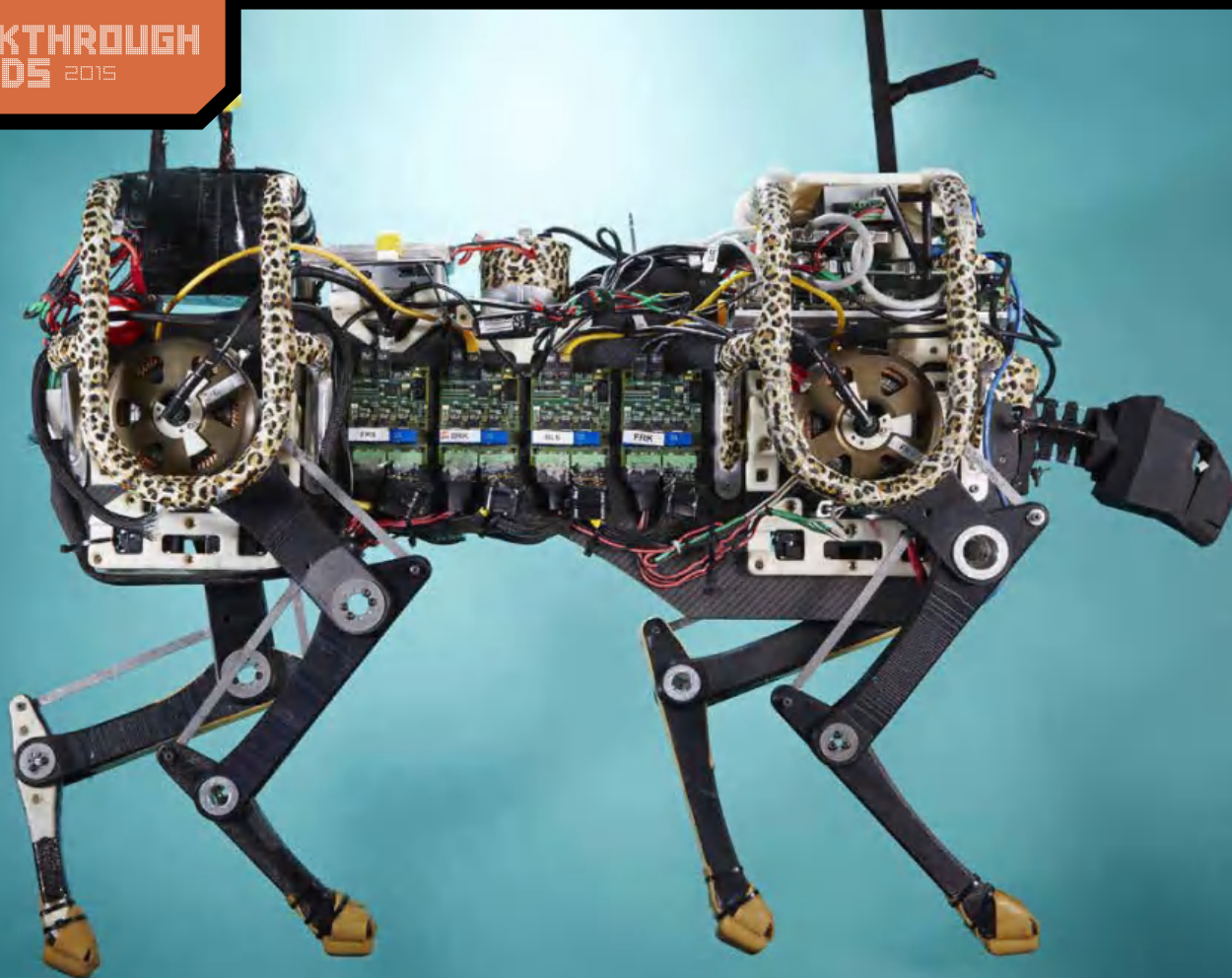
Rodent space runner (teen): A hamster ball with a frame that uses Velcro to attach to the wall and keep the ball in one place.



All-in-one container (junior): Reservoir with drinking spout and three storage bays that can be closed with plexi-glass or Velcro.



Sweet smell fly trap (junior): Uses a piece of fruit and a one-way entrance to trap any flies that may escape from experiments.



THE ROBOT CHEETAH CAN NOW JUMP

When MIT's robotic cheetah was introduced in 2013, it was a big deal. Yes, it looks more like a buffalo and can scamper only about 21 km/h, but "its applications are world changing," says project leader Sangbae Kim. This year the cheetah became an even bigger deal. Along with the ability to run without support, it can now use its LIDAR system to "see," adjust to, and jump over obstacles at 8 km/h on its own, with no human input. While the cheetah could be used in military applications such as recon missions or traversing dangerous ground, Kim envisions a world where wheels are essentially obsolete: new accessibility for people who once used wheelchairs, faster and more robust disaster relief, and travel that is no longer hindered by the need for flat, paved roads.

A BETTER BOMB TEST

Whether it's first responders or soldiers in the Middle East, when the order comes for a bomb squad to deploy, they've got to do it quickly. Which isn't easy, considering that they wear full bomb suits and carry hundreds of kilograms of detection equipment. If you could limit the weight and processing time of that equipment, you could make bomb squads more nimble. And if you could make them more nimble, you could save more lives.

In the past analysing a mysterious substance often meant taking a sample from the scene back to a lab – a time-consuming and possibly dangerous

detour. Hours could be spent determining if a substance were an explosive, a deadly toxin, or simply harmless chemicals. But this year **Thermo Fisher Scientific** introduced Gemini, a first-of-its-kind handheld spectrometer that combines two separate chemical identification technologies in one lightweight unit. Raman spectroscopy, which measures the amount of light scattered by a substance, works best on semitranslucent containers, liquids, and fluorescent powders. Fourier transform infrared spectroscopy (FTIR) measures the amount of light absorbed, and works best on the other stuff: coloured substances and samples that emit light. The 2-kilogram device has an on-board database of 14 000 substances and its

own anvil for precisely crushing samples. That anvil can even be set to a timer, allowing operators to retreat to a safe distance. Using Gemini, bomb squads can now analyse a much larger range of substances on site. And the results are nearly immediate.

– DAN DUBNO **PM**



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By entering the competition you will receive a free 12-month subscription to Getaway magazine and be entered into a draw to win a holiday package to the value of R50 000*. The winner of the holiday package will be randomly selected via a draw. The decision will be final and the winner will be contacted and notified via telephone and email by Thule Sport and Cargo SA (Pty) Ltd. If the winner is unreachable 2 weeks after notification they will forfeit the prize. The winner will be allowed to choose from three holiday packages (for more information on these packages speak to your Thule Partner Store). The holiday must take place in 2016. The prize is not transferable and may not be converted into cash. The competition closes at 6pm on the 31st of December 2015. No late entries will be accepted. The winner of the competition indemnifies the organisers and all parties involved in this competition against all claims that may arise from utilisation of the prize. Entrance of this competition constitutes acceptance of the rules. * may vary within a 10% discrepancy of the value claimed.

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PM TESTED

ENLIGHTENING

A modern take on the age-old lantern

Lanterns have been around for millennia, from the traditional Chinese paper lantern fitted with a candle, to the hurricane lantern – of which the original is believed to have been invented in 9th-century Baghdad. The technology behind the lantern might have changed over the years, but many households still count on it as a light source when load shedding plunges the nation into darkness. For campers, lanterns are a practical – even primal – need. In suburbia they morph into décor, adding a chic sheen to a drab garden. For PM, it's an opportunity to seek out the best of the best.

BY NIKKY OOSTHUIZEN



PHOTOGRAPH BY BIANCA LIEBENBERG

ENERGIZER MULTI-PURPOSE LANTERN

LUMENS: 30

RUN TIME: 2,5 hours

BULB TYPE: Fluorescent tube

POWER: Charge with two-prong plug

HEIGHT: 26,6 centimetres

WEIGHT: 1,58 kilograms

PRICE: R499

BUY IT AT: Major outdoor retailers

Likes: Has an auto-on function, able to detect a power failure. The two-prong plug can be hidden inside of the lantern housing.

Dislikes: The mounting slot is at an odd angle and the lantern is almost too heavy to hang.



UST 30 DAY/GLO LANTERN

LUMENS: 300

RUN TIME: 32 hours

BULB TYPE: LED

POWER: 3x D-cell batteries (not included)

HEIGHT: 18,5 centimetres

WEIGHT: 450 grams (batteries included)

PRICE: R599

BUY IT AT: Exclusive to Cape Union Mart

Likes: The rubberised housing glows, which makes it easy to find in the dark.

Dislikes: Uses D-cell batteries, which are long-lasting, but expensive.



ULTRATEC SOLAR CARAVANA-S

LUMENS: 500

RUN TIME: 3,5 hours

BULB TYPE: LED

POWER: Solar panel, electricity via USB

HEIGHT: 24 centimetres

WEIGHT: 868 grams

PRICE: Not yet set

BUY IT AT: Major outdoor retailers soon

Likes: Has a sturdy rubberised housing. It can charge digital devices, and be charged via USB.

Dislikes: The solar panel's housing is made from a more fragile plastic than the rest of the lantern, and seems less protected.



SAVIORLITE LED CAMPING LANTERN

LUMENS: 200

RUN TIME: up to 20 hours

BULB TYPE: LED

POWER: 3x AA batteries (not included)

HEIGHT: 23,6 centimetres

WEIGHT: 419 grams (batteries included)

PRICE: R299

BUY IT AT: Major outdoor retailers

Likes: Sturdy, but lightweight. Able to light a dining room or tent very well.

Dislikes: Powered exclusively by batteries.



SECUR LED SPOTLIGHT & LANTERN

LUMENS: 32

RUN TIME: 135 minutes

BULB TYPE: LED

POWER: Dynamo generator, electricity via USB

HEIGHT: 18,4 centimetres

WEIGHT: 319 grams

PRICE: R499

BUY IT AT: Exclusive to Cape Union Mart

Likes: Comes with a built-in torch and flashing emergency light. It can charge digital devices with its 300 mAh rechargeable battery.

Dislikes: Very dim and best suited to emergency use.



ASUS ZENBOOK UX305

Fruit skewer

YOU NEED ONLY TAKE ONE LOOK at the new Zenbook's all-metal design to know what Asus has its sights set on as a competitor. It looks like a Macbook, but is a little different. Well, a lot different. Windows Ultrabooks have always nailed the design and ergonomics parts of the premium equation, but this model wins with silent operation (thanks to the fanless Intel Core M chipset) and impressive, consistent battery life which regularly stretched to nine hours on the trot.

Yes, the Core M isn't the most powerful processor on the block, but you're not going to be editing animated movies or playing serious games on this. No, this is your workhorse that sustains you on the go. With a quality 1080p 13.3-inch screen and 8 GB of RAM complementing the 256 GB solid state drive and three USB 3.0 ports, I was never found at a loss for speed. The only loss I felt was for words when trying to pen some in a dark room without waking my wife. No backlit keyboard in 2015? Really?

Irritatingly the machine didn't come with Windows 10 pre-installed or a touchscreen display, but neither of these were deal breakers. Same goes for the network cable via USB port – not my favourite, but most people use Wi-Fi now



anyway. The Zenbook UX305 is a great portable solution that may convert a few Macbook users sitting on the R12 000 fence.

JUST THE FACTS:

SCREEN: 13.3-inch, 1 920x1 080, IPS LCD

MEMORY: 256GB SSD, 8GB RAM

CONNECTIVITY: 3x USB 3.0, Bluetooth, Wi-Fi

PRICE: R11 999



SPHERO BB-8 DROID

Balls of fun

IF YOU'RE FAMILIAR WITH the original Sphero ball, then you already know half of what the BB-8 can do, which is roll around in the direction of your choosing. Sphero has now stuck another plastic bit on top of the ball and partnered with Disney, which also adds some context and personality to the oddly desirable toy.

The best thing about BB-8 is feature called "Patrol". Put the toy in this



mode and it heads off on its own – with sometimes hilarious consequences, like that time it slipped into the ladies' bathroom. Although the beeps and buzzes are played through the controlling smartphone, all the animations and movements are true-to-life of the on-screen droid in the upcoming movie.

Other augmented reality gimmicks like the holographic communication are fun, but I found myself leaving it in patrol mode to see how it responds to the environment more and more. And was rewarded by its ever-increasing and endearing personality – which is a sentiment straight from the marketing sheet, but something I truly believe happened.

There's no practical reason to get a BB-8, but as far as official movie merchandise goes, this is another winner from the *Star Wars* brand. May the force be with your wallet.

JUST THE FACTS:

COMPATIBILITY: iOS (iPad 3rd Generation or newer, iPod 5th Generation or newer, iPad Mini or newer, iPhone 4S or newer), Android (4.4.2 or higher)

CONNECTIVITY: Bluetooth, NFC

PRICE: R2 799

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HUAWEI P8

Turning point

THE LOCAL LAUNCH EVENT

of the P8 took not just a page, but the marquee and event straight out of Samsung's Galaxy S5 playbook. But that's also where the similarities end. While last year's Samsung flagship was derided for its plastic build the P8 stuns (yes) with a marriage of 6061 aluminium and Gorilla Glass. It's slippery in the hand, but a slender profile and miniscule bevels let you wrap just enough flesh around it to feel safe. Internals on our version will handle all signal bands, push the pixels on the 1080p 5.2-inch screen around quite effectively and 3 GB RAM makes for snappy response and good multi-tasking. And that's where things start to fall apart. When Huawei fiddled with Android 5.0 (Lollipop) to make it suit the iOS cloning Emotion user interface, the developers broke some important functionality.



You can get the app drawer back with a launcher, but there's nothing to save you from aggressive background task-ending hell. Connecting a smartwatch via Bluetooth 4.1 is a nightmare because the phone will either respond with a persistent background power consumption notification, or just kill the connection – turning your smartwatch into just a watch. And when you reconnect, then it makes you request permission to access the notifications again. Every time. The stock music player also refuses to automatically detect files on the SD card, so Play Music is the way around that.

Although the P8 is undoubtedly an amazing device, there are just far too many workarounds needed to make it run like an Android device. I used the Google Now launcher in the final week and the phone morphed into a brilliant beast.

If the Chinese company could produce a device with a mainstream chipset and a near stock Android experience, the developers will flock to it. This isn't that device and seems fated to follow its P6 and P7 predecessors into anonymity. There is a Huawei Nexus device out in the wild now, and hopefully that will inspire greatness in the forthcoming P9.

JUST THE FACTS:

SCREEN: 5.2 inches, 1080p IPS-NEO LCD

RAM: 3 GB

MAIN CAMERA: 13 MP with optical image stabilisation

FRONT CAMERA: 8 MP

STORAGE: 16 GB with micro SD card slot

OPERATING SYSTEM: Android 5.0.2 with Emotion UI 3.1 enhancements

PRICE: R7 999



TOMTOM BANDIT

Truly wireless

IN THE ACTION CAMERA MARKET, you can't beat the GoPro at everything, but you can do one thing really well. TomTom's Bandit is ridiculously simple to operate and that's why it has been my go-to video camera for the last couple of weeks, even though I had the more compact GoPro Hero 4 Session at my disposal.

In the November issue I praised the Session for changing my perception of action cameras, but the Bandit's excellent smartphone app and on-camera user interface take a lot of the guesswork out of shooting video. This still doesn't help my terrible framing when shooting impromptu, but the ease of editing more than makes up for that.

Irritatingly, the same genius design that makes you remove the core to plug straight in to a USB port for simultaneous file transfer and charging means you can't plug the camera to a power source and shoot, say, a 6-hour timelapse. And your mileage may also vary with regard to learning the four-way navigation pad controls – luckily my TomTom Cardio Runner watch shares the interface.

In all, the Bandit is the easiest-to-use action camera I've tested and comes bundled with a GoPro-compatible, erm, mount, so you can plug directly into your existing eco-system. Be warned, the Bandit's form factor is somewhat different.

PM

JUST THE FACTS:

VIDEO RESOLUTION: 4K @ 15 FPS (timelapse @ 30 FPS), 2.7K @ 30 FPS, 1080p @ 30 or 60 FPS, 720p @ 60 or 120 FPS

STILL RESOLUTION: 16 MP

BATTERY SIZE: 1 900 mAh (about 3 hours of continuous 1080p @ 30 FPS shooting)

PRICE: From R5 799



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The future of water supply in South Africa is a twisted tale of corporate, social and governmental responsibility, and drinking your own wee.

STORY AND PICTURES BY LINDSEY SCHUTTERS

DROUGHT IS THE *new normal*

In 2009, the lush green southern Cape was declared a disaster zone. The headlines proclaimed it the worst drought in one hundred and thirty years. Millions of rand were ploughed into damming the Breede River, desalination plants and, as a temporary measure, trucking water from George. With gardens and agriculture being the biggest leeches on our water supply, it's telling that this fate befell the famed Garden Route. Also more telling is the speed at which local government acted to alleviate the cost of trucking water from nearby towns, a harsh reality that has long faced Northern Cape towns. But yet, even with a water restriction sign up in my guesthouse bathroom, I still kept the shower running while lathering up with shower gel. It can't be that bad, surely?

Water demand in Cape Town has reached capacity. The Department of Water and Sanitation estimates that the Berg River dam project has pushed back the crisis date to 2022, with the Table Mountain Group Aquifer, seawater desalination and augmenting of the Voëlvlei dam earmarked as measures to deal with 2035's worst-case scenario 800 million m³-a-year consumption needs.

Up north is a similar story, with the capital implementing severe water restriction in early October, and Johannesburg following suit after an early spring heatwave. Move into the Free State and the picture doesn't get any better because







(Above) Even though it isn't currently in operation, Calvin Jafta is quite fond of working on the Sedgefield 1,5 million litre desalination plant.

(Far right) Unit 1 of the two identical reverse osmosis semi-permeable membrane filters can produce 750 000 litres of fresh water per day, at around an 85 per cent yield. The membranes are designed for the site's specific water quality and salinity.

(Right) The pump room that sends the fresh water to the holding tanks.

Not pictured: puffadders



poor rainfall meant that in August government had to intervene by releasing water from the Limpopo Highlands Water Project to help refill the province's dams.

Weather SA is predicting lower than usual rainfall for summer 2015-2016 due to a strong El Niño presence in southeast Africa. South Africa needs an intervention.

STANDING IN FRONT OF ONE SUCH intervention at Sedgefield's Myoli Beach doesn't inspire confidence. This plant was the workhorse in the recovery period after the 2009 drought, processing up to its 1,5 million litre daily fresh water capacity at regular intervals. The inconvenient truth is that the plant isn't currently working and might never come online.

Knysna Municipality Technical Services Superintendent Calvin Jafta doesn't want to get involved in the politics though, he only wants to show off his baby. "When you walk in, just look in front of you. We've had to call in the fire department twice because of puffadders," explains the thoughtful middle-aged man.

Inside the container is the first of two identical units that can produce 750 000 litres of fresh water per day. Water is pumped from ocean boreholes through the award-winning bag filter system to remove solid particles, then through banks of carbon filters and finally into the reverse osmosis membrane. It's a standard set-up, but each company has its patented technology. This particular system was designed by NuWater (Knysna and Mossel Bay plants are Veolia designs). From the RO filter the water is then pumped through a pH balancing system and into storage tanks, ready to be reticulated.

"When this plant was running, I could only run during off-peak times. It cost about R10-plus per kilolitre. That's why Eskom didn't want to give us power," Jafta says of the energy needed to turn seawater into drinking water. "When the Eskom parameters were green, I was here running the plant through the night. After a three-hour period you get up to check if everything is still working, if the valves open, because NuWater (the developers) can call in to change the sequences if you're not alert. This is a very nice plant and I liked working on it."

Jafta monitors the Sedgefield district water supply and is involved in every project affecting the area. The Karatara river weir, for instance, was installed after he detected salt water flowing upstream. What happened was the municipality opened the Swartvlei mouth after fears of flooding, but the sea then pushed in around 20 km upstream. "That was the first time I saw it, but it happens regularly now. When it's not raining, at high tide the water goes upstream and we get saline water. The weir is designed with mechanical gates (which act automatically) that open when the water flows downstream and close if the flow rate is higher upstream."

The award-winning project was designed by Tuiniqua consulting engineers and incorporates a fish ladder to help the natural inhabitants overcome the man-made structure. This intervention also traps enough water to sustain Sedgefield for 10 days if drought conditions hit the area again; this should be sufficient time for the municipality to mobilise other emergency measures.

At peak summer periods, the region is flooded with more than 14 000 holidaymakers, more than doubling the population. And many of those people own homes in the area and sit on the Wilderness and Lakes Environmental Action Forum, which is another headache for Jafta. "I'm working here in Sedgefield for almost 13 years, mostly in the water environment. I see over the years what's happening and then the engineers come here because they have places and they've all got their own opinions and say 'It should work and it must work'. You rather don't argue because it makes you feel dumb," he explains.



Award-winning ideas

The NuWater desalination plant in Sedgefield is neither the biggest in the country, nor is it the most efficient, but it has won two industry awards for innovation.

When water is pumped through the reverse osmosis filter, the brine that collects is then cleared and backwashed out into an energy recovery system. It's basically a turbocharger that uses the escaping brine to spin up turbine which in turn assists the pump. Calvin Jafta says that when the plant is running, you don't hear the pump, but rather the turbo. This system equates to a 30 per cent energy saving.

Part of the reason why the Sedgefield plant is out of order is that gale-force winds and unusually rough seas left the inlet pipes exposed, sucking in sand and other debris. The initial screening filters were the cartridge type, which would clog easily. The filters were replaced with easier-to-maintain sandbag units, which essentially work like swimming pool filters and can be cleaned out daily. Jafta says that he'd regularly encounter condoms and underwear in the filters.



(Left) The energy recovery system is, essentially, an elongated turbocharger. (Below) Bag filters are easier to maintain than cartridge filters and cheaper to replace. Desalination technology is global and South Africa has the same access to it and produces the skills, but the high energy costs are prohibiting a mass movement to these innovations.





(Above) Although there is no science to support it, flow forms have shown to be effective in this specific water treatment system. And add a nice aesthetic.
(Right) The Ying-Yang pond is a completely ornamental feature.



"I learn, and what I learn in the book and the reality here on the plant is a moer of a difference." He argues that the engineers – his superiors included – are sometimes too fixated on data, using pH levels as law. "We must give the consumers a pure colour. They are not looking at the pH. You can adjust your pH afterwards; first get the colour. I respect the engineers, but they should also come down here and respect me for what I'm doing."

What Calvin Jafta is doing is vital to Sedgefield's continued existence. His team is currently paying much-needed attention to the boreholes around Sedgefield and placing proper concrete platforms under the pumps. It's a small maintenance job, but important for the long-term reliability of that water source. The rest of his schedule is filled by regular patrols around the area to police unscrupulous water use. He shares an anecdote about a property supposedly using its rainwater tanks for irrigation, but instead municipal water was used. Property developers and builders are also water thieves who have felt the wrath of municipal fines.

CAPE TOWN'S 2022 DOOMSDAY water deadline is fast approaching, but the region's wine industry contributed

R36,1 billion to South Africa's GDP, according to the South African Wine Industry Information and Systems report. The report analysed the industry from 2008 to 2013 and found South Africa to be the eighth-largest wine volume producer in the world, providing employment for close to 300 000 people, 56,7 per cent of whom are based in the Western Cape.

The agriculture sector, however, accounts for 43 per cent of the province's water use. With one cubic metre of water only yielding an average of 3,7 kilograms of wine grapes (according to a Dutch study that referenced satellite imagery and rainfall data from 2004 to 2007), the wine industry has its water conservation work cut out for it.

Andrew Hulsman is a process engineer at HWT and the man to talk to when you want to know about the waste water treatment plant at Spier wine farm. As in most of the private sector, green initiatives are big currency for Spier. Hulsman explains that the treatment plant reclaims about 150 000 to 250 000 litres of waste water per day, which then is piped to the toilets on the estate. The effluent is pumped through six pump stations and is comprised of waste water from the winery, restaurant, laundry and domestic sewage (poo) from the staff, residents, hotel and public bathrooms.



(Above) Spier's bioreactor houses an unthinkable number of bacteria, which feast on harmful microbes by interrupting chemical bonds. Similar sites are being added to our municipal treatment works.

(Left) Andrew Hulsman lets out some of the slurry, which is then sun-dried and sent to the municipal landfill. The high salinity makes it unsuitable for compost in this form.

HWT have an Archimedes Screw patent that they installed to catch large particles, but because some of the waste water is generated in the kitchens of the estate, grease is the biggest problem. The grease caused such regular blockages that the engineers needed a cheaper solution. That solution came in the form of the same plastic mesh bag that your vegetables come in. These are just some of the methods used to preserve the integrity of the billions of bacteria that do the heavy lifting in processing the waste water.

"I like to think of them (the micro-organisms) as an ex-wife. You have to make sure she has a home and you provide for the kids, you try to give them the most comfortable life you can and then put up with the occasional issue," says Hulsman of his relationship with the treatment plant.

The plant is set up in five main processes. First is the mechanical inlet screening, which uses the innovative veggie bag filter called the Dragon Sock. Dragon Socks are changed daily and stored on site before being transferred to the municipal landfill once a quarter. Water is then retained for four hours in the flow-balancing process. From there the screened and settled water is aerated to remove nitrogen and phosphorous and enters the activated sludge bioreactor where the micro-organisms get to

work. So far it's just an ordinary bioreactor plant, but the magic happens when the nitrified water is pumped into the reed bed.

"We selected reeds that were growing nearby because fynbos hasn't been studied to the extent where we know exactly which nutrients the plants are taking out of the water," explains Hulsman. The plants get cut down annually to encourage new growth, but the main focus is in the reeds' ability to strip out all the harsh nutrients carried in the treated water. It's a natural filtration system that has the added benefit of having developed its own ecosystem of birds, frogs and insects in a similar way the brine stripped off of the desalination plant membranes contribute to healthy ocean ecosystems. "We've seen a few threatened species thrive in these conditions and people are always coming out here for bird-watching," he adds.

The reed bed also serves as a backup to the bioreactor because it contains its own population of micro-organisms, while at the same time serving as a water polishing agent.

Water is then pumped into the circulation pond, where it cascades over 15 flow forms. While the effectiveness of water treatment via flow forms isn't fully understood, the engineers have noticed improvements in a number of parameters. The Yin-Yang shape of the pond is also more aesthetic than functional, but the overflow is then pumped into the irrigation storage dam.

Spier's vegetable garden is irrigated chiefly from rainwater storage, but the estate gardens are irrigated exclusively from the reclaimed water. The elephant in the room, however, is the endless rows of vines on the Spier property. Hulsman estimates that it takes around five litres of water to produce one litre of wine, and that's after the grapes are harvested. Take into account that

the Institute of Masters of Wine in the UK reckon a commercial winery has a conversion rate of around 500–850 g per litre of grapes to wine and the fresh water cost is mind-bending. But at least the wine farms are making an effort.

Spier is the latest recipient of the Getaway Award for Leadership in Water Conservation at the 2015 Nedbank Green Wine Awards, a testament to the farm's industry-leading advanced treatment of waste water. In combination with recycling 100 per cent of the waste water on the estate, Spier has removed thirsty alien plants and replaced these with more than 53 000 indigenous plants and managed to bring its water to wine yield ratio down to about two litres of water per litre of wine through efficient practices.

ZOOMING OUT FROM THE COUNTRY'S

drought-stricken greener regions compounds the issues. As much as 60 per cent of South Africa's water use is chalked up to agriculture and irrigation, and this in a country with an annual rainfall average that's 40 per cent under the global average, which is enough to be the 30th-driest country in the world.

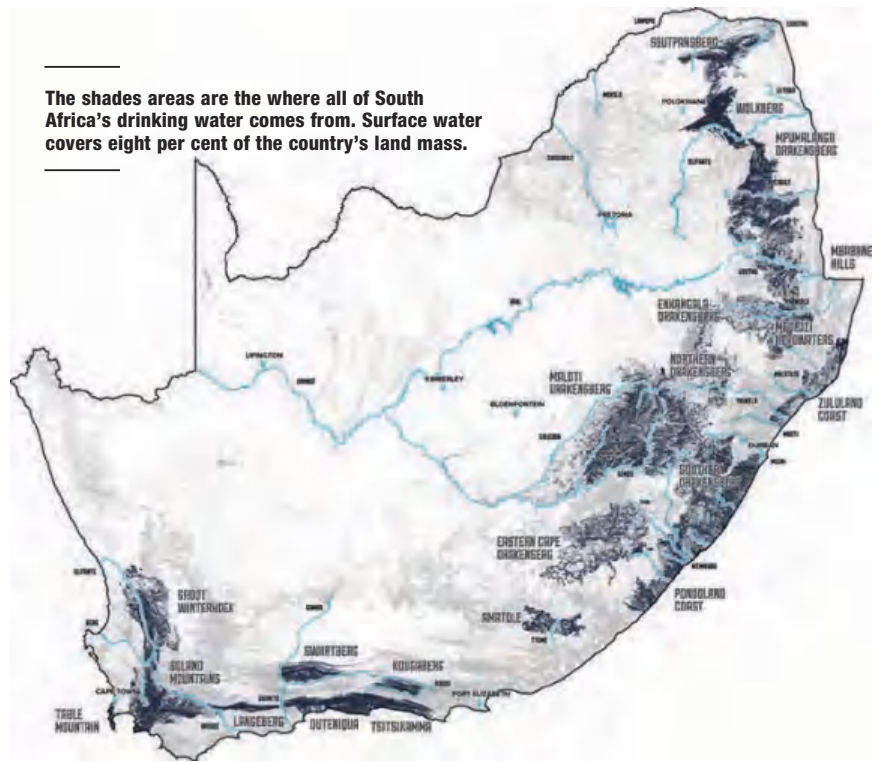
Every engineer referenced for this article sang the same tune with regard to the country's water use and it isn't something we should be dancing about. The situation is dire and it gets progressively worse with every government policy misstep and budgetary blunder. There is a national plan, though, and it relies heavily on increasing water reuse volumes through improved purification technology.

The Blue Drop system of water quality assessment has been heralded as a great success, with only five out of the 132 towns tested across the country failing to make the grade in terms of water quality. This means that although water may become more scarce over the next few years, at least the existing supply is safe to drink. So from the perspective of safety, our tap water is in a good position.

Under the Blue Drop system, Gauteng comes up trumps, with the Ekurhuleni municipality and City of Johannesburg leading the charge to clean water. Acid mine drainage remains a problem, but one restricted largely to coal mines, so the City of Gold is still safe for now. Also, most of the area's water comes from the Drakensberg.

The overwhelming sentiment is that to get to a point of adequate long-term water security, South Africa needs to implement a step-by-step plan that will not only reduce consumption, but also reduce contamination. While there are tax incentives in place for the private sector to go off-grid, this has been the exception rather than the rule and understandably confined to newly constructed buildings. The Fair Cape building in Cape Town's Black River park and Old Mutual's premises in Century City represent two excellent examples of off-grid buildings. A combination of systems support a

The shaded areas are the where all of South Africa's drinking water comes from. Surface water covers eight per cent of the country's land mass.



central desalination plant and ensures water reclamation.

Further steps should be taken to move agriculture and irrigation over to reclaimed water systems and to take outlying communities off the municipality supply.

Turning against the agriculture industry will be kissing away the money from our third-biggest contributor to the country's GDP, and condemning millions of people to a life of hunger and poverty.

BUT THE TRUTH is that the responsibility lies with the consumer, me included. Simple things like closing the tap when I'm lathering up, or using only borehole water to water the garden will go a long way to reducing my consumption. I don't have a swimming pool and I also use the "if it's yellow, let it mellow" code to govern toilet flushing.

Although it would repair a lot of the divisions in our society, maybe not everyone should get a flushing toilet in their home. Not at least until the toilet water is 100 per cent recycled. More services for more people means, ultimately, more sewerage. This will put maintenance budgets under more pressure and system failures could then be catastrophic.

Maybe we should all just pray for rain.

Luckily, the government has a plan and it's called the National Water Resource Strategy 2. In 2013, the strategy called for a R700 billion investment over 10 years to address the estimated year-on-year growth in water demand of 1,7 per cent for the corresponding period. Data shows that domestic water consumption rose from 22 per cent of total use in 2003 to 27 per cent of all consumption happening in homes by 2013. A conservative estimate will then see domestic consumption account for roughly a third of the country's water use by 2023. By all accounts, our infrastructure isn't prepared for that kind of load.

SA's network of around 4 395 dams will, under the terms of the strategy, in future be supported by an aggressive water conservation and water demand management campaign, seawater desalination, catchment rehabilitation and a country-wide drive

to clear invasive alien plants. Water will also become more expensive.

Most intriguing, though, is that 60 per cent of South Africa's river streamflow is shared through trans-boundary water systems. This calls for policies that are sensitive to the country's cross-border relations, while still being compliant with legislation governing water resource management. South Africa was recently forced to cut off water supply from the Molatedi dam in the North West to Botswana's capital Gaborone.

The water supply agreement was penned in 1988 and accounted for 4,8 million litres of water per day, around 16 per cent of the city's daily requirements. The original agreement was that supply would be halved when dam levels reached 26 per cent, but with the region facing its lowest rainfall in 34 years and dam levels at only 8,4 per cent, South Africa had no choice but to take care of its own. A similar move was made by Eskom earlier in 2015 when the government was forced to cut the electricity supply to Botswana in the face of rolling blackouts.

A key component of the master plan will count on changing the population's perception: water re-use. At a river system level, it is estimated that approximately 1 800 million m³ per annum



The Karatara weir represents Sedgefield's first line of defence against the return of drought conditions.

of water flowing in our rivers is return flow, that is used water, accounting for 14 per cent of the total available water in South Africa. At the treatment facility level, South Africa has in excess of 1 000 municipal wastewater treatment works, discharging approximately 2 100 million m³ per annum of treated effluent, back to the river systems.

Don't worry, our municipal water treatment plants are getting the necessary upgrades needed to improve the quality of the final product. The bioreactor

in Bellville South in Cape Town is forging ahead along this path of smaller treatment plant footprint and higher-quality final effluent.

Bioreactors are not only 60 per cent cheaper to build than regular treatment plants, but half the size and require less maintenance. The 2011 tender for the Bellville South project was around R187 million and the plant receives water from the old treatment facility, acting as a final quality control.

The tap water at the guest house in Knysna had a yellow tinge to it and we ended up buying a five-litre bottle of still water at Woolworths to make our baby's formula bottles. My wife actually felt guilty for using tap water to make a bottle on the first night, even though she boiled it beforehand. A simple chlorine-based water clarification pill would've gone a long way to calm our parental fears, and it seems like this is the future of drinking water in South Africa.



Acid under wraps

→ WHAT IS ACID MINE DRAINAGE?

You know all those old mine shafts that are filled up with water? Well, that rock contains traces of other metals that are leaching into the water. We're basically cooking up sulphuric acid right under our cities and it's eating away at the bedrock of our country.

→ WHO IS AFFECTED?

Towns and cities close to coal, uranium and gold mines.

→ WHAT'S THE PLAN?

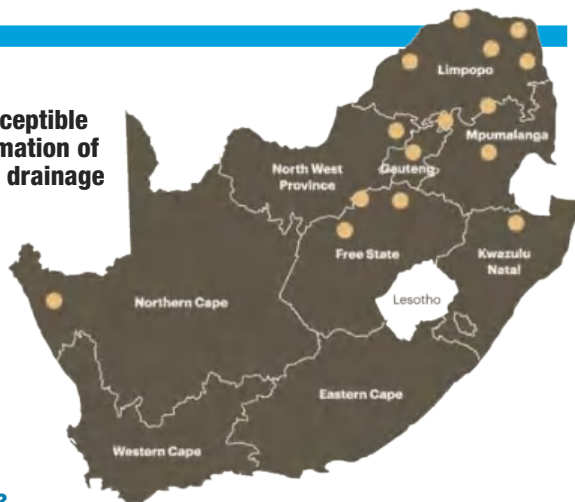
Currently the Department of Water and Sanitation are pumping out the water, treating it and sending it back into the river system so it can form part of our water stocks. This is only a short-term solution, though. Independent analysts are saying that groundwater from the rising water table is filling the mines quicker than acid is

being pumped out, so the strategy is more like chasing a unicorn than an effective measure. Also the partially treated water that's being introduced into our rivers is having a severe ecological impact.

→ SO WHAT'S THE REAL PLAN?

The DWS are still figuring it out, but has involved institutions from Johannesburg and Stellenbosch have been enlisted to work with international partners to formulate a long-term solution. Water will continue to be pumped out, treated and diluted in our river systems, ultimately contributing to our bulk storage that will help alleviate our water crisis. Beyond that there's also another strategy, which involves praying that the rising water table will dilute the water suffi-

● Areas susceptible to the formation of acid mine drainage



ciently. There's a big call to rather recirculate the treated water back into mining practices. The CSIR also have a patent that uses limestone (much cheaper than the lime currently used) to clear bulk heavy metals from water; lime need only be used to treat for low concentration metal levels. Extracting sulphur and calcium carbonate through a barium process is also an option.

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Say IT* with flowers

Virtual currency, a florist on your mobile device, task-performing monkeys... how the Internet of Things is transforming the business of doing business

There's not a bloom in sight in the flower shop, on the first floor of the trendy Woodstock Exchange, along the urban renewal strip that branches eastward off central Cape Town. In the boardroom, the handful of tulips poking out of a vase looks like an afterthought.

Yet... it's all about flowers here. The half-dozen hipsterish types in jeans and sneakers hunched over computer screens are working in computer code and databases, it's true. But what they're really doing is communicating with those who yearn to speak the language of love, of celebration, of sympathy. In other words, with people who want to say it with flowers.

"Everyone wants flowers," says Nicholas Wallander. He runs a tech company that happens to sell flowers. It's been a startling rise, within just a few years, for SA Florist, the company Wallander co-founded with Fraser Black.

It's a success story that starts, ironically, with a flowery failure: the demise of the independent florist run by Wallander's mother. Killed by the Internet. Or rather, by rise of the giant Net-based hyperflorist that dominates the SA market. Not that netflorist willed the independents out of business: just that, given the way the world was moving, the shift to online purchasing has been like a tsunami. In a world of instant gratification, the quick fix and the EFT, it all seems so inevitable. The bald numbers tell the story eloquently: six years ago, South Africa had 2 000 independent florists. Today, there are just 600.

Still, from devastation (Wallander: "A gigantic hole in the balance sheet") emerged, in 2011, a B2B e-commerce start-up that offered an online shopping portal for local flower and gift traders. Nothing particularly revolutionary there.

Until 2014, when, during the first series of *Dragons' Den South Africa*, Wallander and Black secured the



biggest funding. That earned them R3 million seed investment and changed their way of thinking. "We decided to pivot our business from an online retailer into a geographically distributed

marketplace," says lead developer Jean Michel Gaud. He's one of the lynchpins of a heavily tech-focused group, whose staff complement of nine includes a development and design team of three, with two more about to start.

The backbone of their system uses software created by Elastic. "This is actually a unique application of their tech," Wallander explains, though it's technology that has been applied by online vendors such as Kalahari.

Getting flowers from well-wisher to recipient starts online at *saflorist.net*, says Gaud, by asking the question: "Where are you sending to?". This initiates a process of geolocation, which throws up a listing of who services that specific area and shows each florist's unique range of products. Next step is to ask the customer how soon they want their order delivered and then to execute the order.

The technology allows existing capacity to be applied across the world. "We believe it to be robust, scalable system," he says.

A big focus of their current efforts is optimising their web interface for mobile devices. "There is increasing demand for mobile and increasing use of mobile." Not necessarily an app, but "an app-like experience".

If it's so great, why aren't others rushing to do it? The thing is, whereas larger organisations quickly capitalise on the technological revolution, Wallander says, traditional small businesses and upstart entrepreneurs are struggling to keep afloat. With the correct business models, they could be the greatest beneficiaries from the Internet's empowering influence.

In the view of co-founder Black, there's an opportunity going begging in

*Information technology



this third wave of the Internet – the Internet of Things, where everything is connected, from tablets to cars, homes, appliances and wearables. It represents a huge opportunity for manufacturers of devices, providers of services and other businesses that can manage the wave of high-velocity data and find business value for their customers and their markets, he says. (Gartner estimates the total economic value-add from the Internet of Things across industries will reach \$ 1,9 trillion worldwide in 2020.)

But, to many business, the gap isn't always obvious. And, to be fair, the transformation of the marketplace is ever-changing. What can catch business out is the sheer pace of that change.

SA Florist does differ significantly from the industry's biggest player in one respect, Wallander says: instead of despatching flowers from centralised depots, he uses individual florists. The decentralisation allows them to offer what he describes as a very relevant and unique product offering – at the right price. "Why limit customers to a specific product range or have conditions for same day delivery?" he

notes. "The customer doesn't want to be told what he can buy and when it can be delivered."

When we spoke to Wallander, his company was about to launch a premium delivery service, Zoom Bloom. "It operates rather like an Uber-style delivery service," he explains. The big deal: by allowing delivery within a couple of hours, it all but eliminates the traditional model of limiting same-day deliveries to orders delivered before an early deadline. "We say it's waving goodbye to the 12 o'clock cut-off."

But what if the new style of flower delivery develops... um... technology issues? "We offer a 100 per cent customer satisfaction guarantee. Backed by all our partner florists," he says. They represent a little more than 200 members.

In a business like this, validation is one of the key decision-making factors. Ratings are crucial. "That's how Uber and Airbnb work," he adds.

Is this for real? Are the little guys hitting back?

Just for a moment, Wallander slips into missionary zeal mode. "It's about the democratisation of the Internet. It is taking back power.

"And as soon as you start democratisation, you are very reliant on the trust you have in your service providers."

More than that, consumers are starting to demand from the Web some of what they experience in face-to-face transactions, he says. "Customers are becoming more engaged in the purchase," he says. "They are not pre-

The dark side

Virtual money is the ultimate expression of e-commerce. But there are hidden risks, not to mention legal pitfalls, say candidate attorney Lara-Jade Sher and Dawid de Villiers, a partner at Webber Wentzel.

The paperless, no-bank digital currency Bitcoin is the Wild West of finance, where huge amounts of wealth can be created and destroyed in a nanosecond.

Created in 2009 by an unknown person using the pseudonym Satoshi Nakamoto, this cryptocurrency is not printed. It's not controlled. And it is based purely on mathematics.

Bitcoin is the world's first digital peer-to-peer payment network. It is powered entirely by its users, with no central authority. Unlike traditional currencies, Bitcoin is never printed. Rather, it is produced through a process called "mining" during which networks of computers run complex algorithms to record and verify user transactions. For every successful transaction recorded, "miners" are awarded new Bitcoins.

Nakamoto's view was that trust in the ability of governments and banks to manage the economy and the money supply was at an all-time low. Bitcoin offers a solution that is decentralised, not governed by any central authority and needs no faith in politicians or bank-

ers. Bitcoin transactions involve no middleman, unlike traditional currencies, which use banks. There are no transaction fees and you don't need to give your real name to use it, either.

Traders are slowly starting to accept Bitcoin as a form of payment. Many are understandably hesitant, though, because of Bitcoin's negative connotations.

Outside the law?

Bitcoin's increasing popularity has regulators and authorities from around the world wracking their brains to try to make sense of a digital currency that uses encryption and operates without a central bank. It's raised legal and regulatory concerns, including Bitcoin's potential to facilitate money laundering and its status in the regulation of foreign exchange trading. Incidents that have brought the currency under new regulatory scrutiny include the failure of Mt Gox, a Tokyo-based exchange that filed for bankruptcy after losing an estimated \$650 million worth of customer Bitcoins.

Bitcoin has many advantages over traditional currencies, not least its anonym-



ity. It has become the preferred method of payment on the "Dark Web", the online black market where illegal transactions take place without trace. The recently shut down Silkroad platform is an example of an illegal marketplace run entirely on Bitcoin, where anything from murder for hire to military equipment was for sale to the public.

Benefits vs pitfalls

So does Bitcoin hold any practical benefit for law-abiding citizens? The overwhelming response from early adopters: the benefits far outweigh the pitfalls.

They point to its status as a digital asset that can't be copied and presents

pared to compromise on their experience and they want to know who is behind it.”

It's not just about the technology. It's the feel-good factor, too. The engagement. In a way, their model successfully taps into the “artisanal” or “craft” movement increasingly embraced by a consumer who hankers for something more personal, more individual. More *me*.

“Different flowers bloom at different times. It's useful to be putting that power in the hands of the florist and that choice in the hands of the consumer.”

It's an ideal model for perishables. So it makes sense to expand, as they are doing, into other areas. If you are buying flowers, for instance, it's likely that you also have on your mind things such as artisanal chocolates. Or wine. Or coffee.

Wallander doesn't doubt that others will tread the same innovative path he has, either. But it's all good, because we're taking back the power we ceded to the giants. And there's something else he's counting on: human nature. “Humans,” he says, “will always support the underdog.”

TRAINED MONKEYS — FOR HIRE

ON THE BASIS of cutting out the middleman and directly connecting with consumers digitally, Task Monkey is also tapping into the connectivity that has led to the rise of Uber, AirBnb and, now, SA Flower.

Like Uber, Task Monkey brings a solution for a customer with a need, and matches that solution with somebody who has the opportunity to fulfill that need. (The needs, we're told, are entirely above board.)

Forsaking what he describes as the monotony of a career in the pharmaceutical world, Johan Cilliers has established the venture, which is both a website and mobile app – like Uber. Users with a task that needs doing register for free, log in, offer a suitable fee and allocate their task to a willing “monkey”. The “monkey” can also “browse” for tasks on the website. Some monkeys are certified professionals and all are skilled, registered, have had their background checked and are deemed safe by the company. Tasks are allocated in three main categories:

- Technical (install DStv, Internet or a wireless network, show granny how to send an SMS);
- General (assemble furniture, fix a toilet, do shopping);
- Deliveries and transport (deliver a package, move furniture).

TaskMonkey charges a 10 per cent administration fee on each task completed and payments are done via PayFast. Fees are held securely until both parties, client and Task Monkey are satisfied.

Business, it's said, is booming after just three months.



Authors De Villiers and Sher: use Virtual currency like Bitcoin at your risk.

The SA view

In South Africa, Bitcoin falls under the Financial Intelligence Centre Act 38 of 2001 (FICA). By simply following FICA rules and regulations, local companies such as BitX – South Africa's only Bitcoin trading

platform – can operate legally and freely, allowing innovation and rapid development.* However, as there are no laws or regulations that deal with virtual currencies, there is no legal protection for users of these currencies. As virtual currencies are unregulated, they can't be seen as legal tender. Merchants are entitled to refuse Bitcoin as payment, without breaking the law.

The South African Reserve Bank has warned about these risks, noting that Bitcoin has no legal status or regulatory framework. Those who choose to use it have no guarantee of security, convertibility or value. The Reserve Bank is monitor-

ing developments around virtual currencies for future regulatory approaches that may be needed in the South African legal system.

The Reserve Bank's recent position on Bitcoin follows the news that Standard Bank had been running a Bitcoin trial, which it later stated would not be launched to customers. The trial was developed by a company called Switchless, and was run to test whether Bitcoin would work in a large banking environment.

Despite Standard Bank's decision, a few South African companies are accepting Bitcoin as a payment method, predominantly in the Western Cape. You can use it to pay for a taxi, takeaways or even a manicure.

The introduction of Bitcoin as a new, unregulated, virtual currency presents new possibilities. But the fact that it has no central point of control and exists only on the Web will make this cryptocurrency difficult, or even impossible, to regulate. Yet, although the future of Bitcoin remains to be seen, it's clear that virtual currencies are here to stay.

* The Financial Intelligence Centre Act requires all accountable institutions, which include Bitcoin exchanges, to verify the identity of every customer. By complying with the FICA regulations, these South African companies ensure they can operate within the boundaries of existing law while still enjoying the freedom of innovation and rapid development.

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no counterparty risk, can't be reversed and largely eliminates the potential for fraud. It is borderless, fast, cheap and easy. Bitcoin offers lower transaction costs and is free, in some cases, offering more privacy and anonymity. To prevent inflation, certain measures were taken in addition to keeping the total number of Bitcoins in circulation to 21 million at most.

Early adopters, such as the Winklevoss twins, the brothers known for their legal battle with Facebook founder Mark Zuckerberg, believe the controversial cryptocurrency is the payment network of the future. They believe that Silkroad was an expected teething problem on the currency's road to success.



At watt cost?

Finding out how you use energy – and how much – is the first step in being able to cut down effectively, says Lionel Smith.



DO WE KNOW HOW MUCH ELECTRICITY CAN BE SAVED by using low-energy lighting such as LEDs? Or how much electricity is saved by turning off lighting when not in use?

Finding out how much electricity is being used by one or all of your appliances is the first step in being able to cut down on consumption, and in doing so spending less on electricity. It goes without saying that reducing your consumption equates to doing your bit towards creating a sustainable world.

Glyn Hudson, Trystan Lea and the rest of the team at *OpenEnergy Monitor.org* developed some monitoring technology to help us understand and optimise our energy consumption and generation. This allows us to approach the problem of energy consumption in a logical and informed way.

Their latest piece of kit is dubbed the *emonPi*, and uses the same Raspberry Pi single board computer that was featured in the June issue of this magazine, where it was used to create an in-car entertainment system.

The Raspberry Pi isn't great at measuring analogue voltages, so various Arduino-based measurement boards have been developed that process and digitise the inputs and transfer them to the Pi. In early 2014, an idea was born to create a shield that plugged directly on to a Raspberry Pi to make a single unit energy moni-

toring solution, primarily aimed at domestic users. A whole bunch of discussions and a fair amount of blood, sweat and tears culminated in a Kickstarter campaign that raised a little over half a million rand to help bring the project to life

The Raspberry Pi based *emonPi*, which is an open-source, web-connected, energy monitor and gives you the ability to measure home energy, solar PV, heatpump generation and temperature. Everything on the Open Energy site is fully open-source, which means you are free to tinker and improve to suit your needs. There is a very active community, so help is readily available.

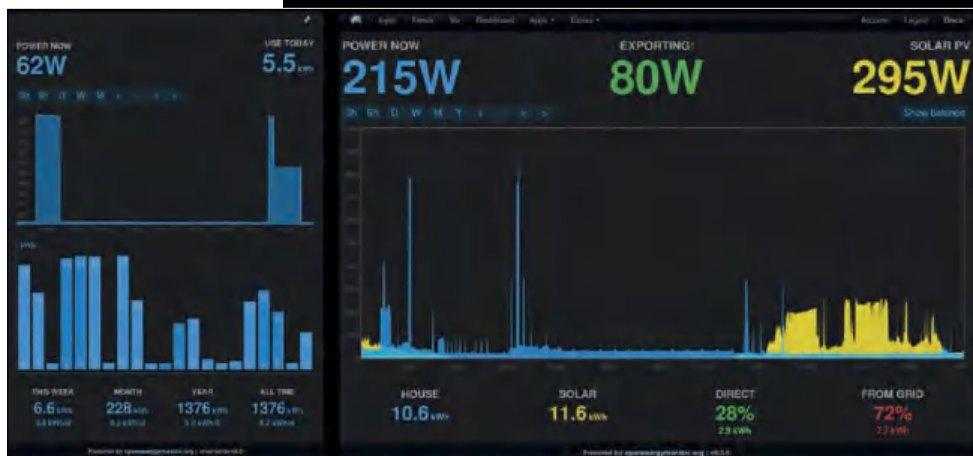
Aside from the obvious current and voltage values, temperature and humidity can also be measured by adding the appropriate nodes. All this information is then formatted on the Pi and either stored locally or uploaded via an Internet connection to a hosted application called *Emoncms*. Once you've built up some data, various visualisations can be applied to create some really informative graphs.

The *emonPi* is available in both kit form or as a complete unit. Complete units are housed in a professional-looking case sourced from Lincoln Binns. Even if you can't resist the urge to experiment and order your system in kit form, it is highly recommended that you order the aluminium case to house the finished unit. Aside

'Measurement is the first step that leads to control and eventually to improvement.

If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it.'

– H James Harrington



from protecting everything inside, the case really gives the unit a polished, professional look.

Inside the case you will find a standard Raspberry Pi 2, the GPIO serial connected Arduino measurement shield and an I2C connected 2 x 16-character display. The unit contains built-in 433 Mhz low power RF, which is used for communicating with its external nodes. These nodes can be used to add additional power readings (emonTx) or remote temperature and humidity (emonTH) .

Fire up the system with a LAN cable plugged in and the on-board display conveniently displays its IP address. Punch that into your favourite browser (on a PC in the same LAN) and you get to the login page. Once logged in, you are able to set up the Wi-Fi if you have added an external USB Wi-Fi adaptor.

The built-in 16 x 2 display will also confirm the status of connected devices. To measure temperature, an optional DS18B20 temperature sensor needs to be connected. The emonPi can talk to multiple (up to six) sensors as they are individually addressable.

Power can be measured using a clip-on CT current sensor and a 9 VAC reference supply. You can cheat and omit the 9 VAC supply input, resulting in the AC voltage being fixed in the software, but then you are not reading true Real Power or Power Factor, so this is not recommended. If measuring solar PV, two clip-on CT sensors are required and the 9 VAC voltage input is essential as it's required to tell the unit if you generating or consuming power. The second CT can be used to isolate a particular load and see how much that draws. As an example CT 1 could be measuring the total of your house, while CT 2 could tell you how much just your water heater or stove uses.

Another method to measure power is to use an optical pulse counter sensor that picks up the LED flashes generated by most modern electricity and gas meters. Being able to visualise the power used by your appliances gives a whole new insight into the power needed

to run them. The author used the system to evaluate the claims made by the supplier of a hot water boiler control unit that allows the boiler to heat the water only three times a day based on your predicted use. Using the emonPi and Emoncms system, it was easy to see exactly how much saving was achieved after installing the control unit.

My conclusion: the emonPi is a fantastic piece of kit and well worth having if you would like to contribute towards a greener future.

● To find out more from Lionel, contact him at info@atwattcost.co.za



Safety warning: Interfacing with mains voltages can be potentially lethal. If you are not competent, or not sure of what you are doing rather seek the assistance of a qualified professional.



Weblinks for more information:

emonPi User Guide: <http://openenergymonitor.org/emon/modules/emonpi>

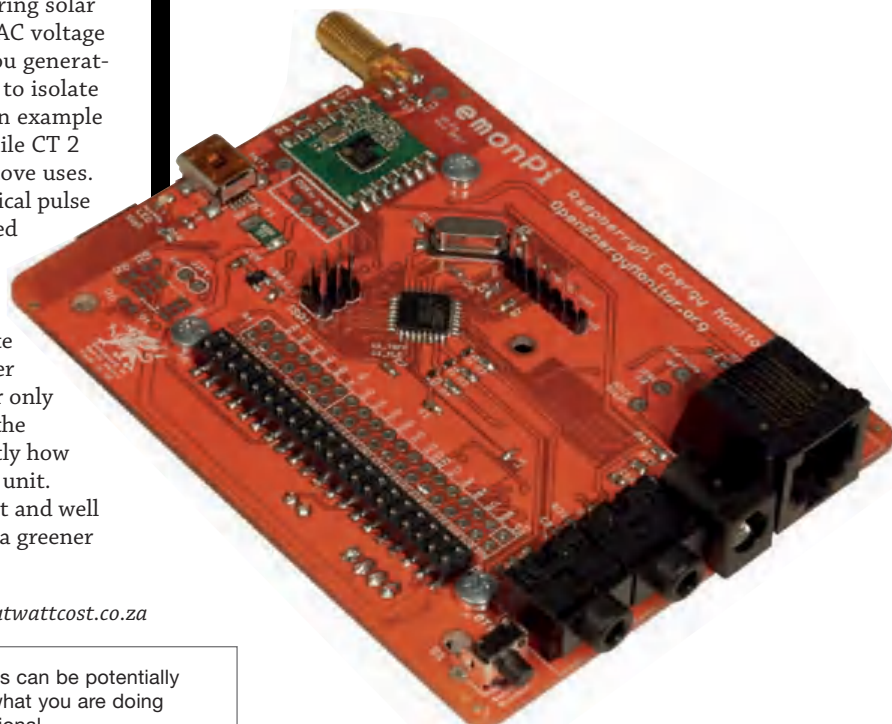
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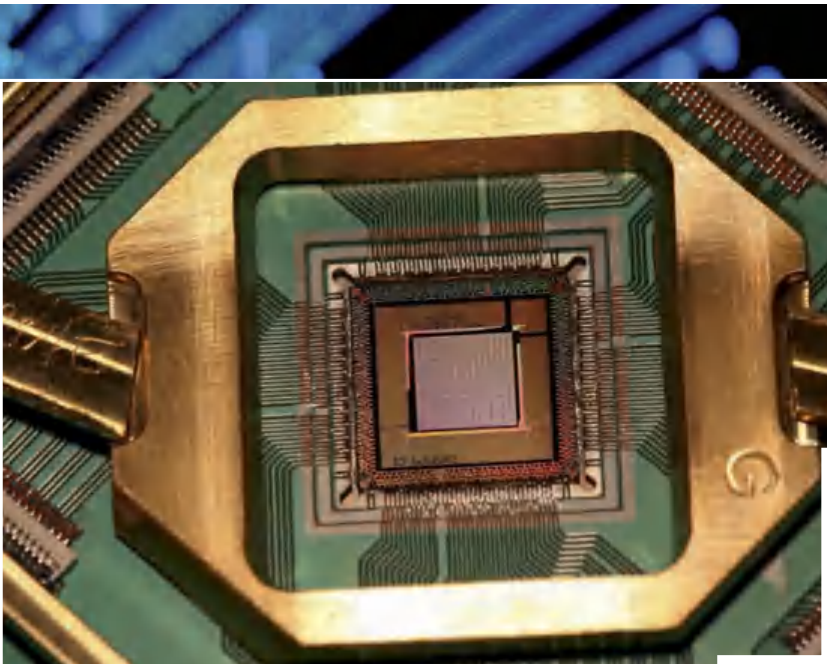
CRACKING



THE CODE

THE EMERGENCE OF POWERFUL QUANTUM COMPUTERS COULD RENDER MOST CONVENTIONAL FORMS OF DATA ENCRYPTION OBSOLETE.

BY FANIE VAN ROOYEN



D-Wave's 1 000 Qubit quantum processor is built from a lattice of tiny loops of the metal niobium, each of which is one quantum bit, or qubit.

QUANTUM COMPUTING: How it works

Conventional computers use switches called bits, which can either have a value of 1 or 0, to compute. In quantum computing, the basic principles of quantum mechanics are exploited to exponentially increase processing speed and power. These principles, that allow for the creation of quantum bits, or qubits, are:

- **Superposition.** The ability of a qubit to have a value of 1, 0, or both (1 and 0) at the same time.
- **Quantum tunnelling.** Information can move from one qubit to another without being anywhere in between.
- **Quantum entanglement.** What happens to one qubit can affect another, even if they are in different places.

These principles, which seem kind of spooky (and which scientists still don't completely understand), enable quantum computers to consider, evaluate and manipulate all known combinations of qubits at once, making computation incredibly powerful and fast. By solving for the minimum energy value across multiple qubits in a system, a quantum computer can almost instantly find the lowest-energy value that represents the best solution to a complex problem.

Data is the currency that bankrolls virtually every aspect of our everyday lives – which is why its authenticity is crucial and encryption is a necessity to safeguard it. Compromised data is not only worthless, it could be dangerous, too. And there's a massive looming threat to data security in the form of the emergence of powerful quantum computers, which could render most conventional forms of data encryption obsolete.

Because new-generation quantum computers are so much more powerful and faster than the norm (see "Quantum computing: how it works"), they can easily crack conventionally generated encryption. This was the warning recently voiced by Professor Francesco Petruccione, a theoretical physicist at the University of KwaZulu-Natal and head of the UKZN Centre for Quantum Technology, during his presentation on quantum cryptography at the 2015 CSIR Conference in Pretoria. According to Petruccione, the world of information security has already entered into a "post-quantum era" because experts have known for some time that a true quantum computer will inherently be able to easily break most well-known conventional public-key cryptography techniques used to protect the secure flow of information over networks (such as RSA encryption, Diffie-Hellman key exchange and Elliptic Curve cryptography).

Luckily, the same principles of quantum physics that allow for the possibility of quantum computing also allow for the creation of potentially unbreakable encryption techniques. Quantum cryptography is already widely used and promises to protect the world's data in the coming quantum computing era. Petruccione and his team at the CQT are working hard to help lead this charge.

ARE WE THERE YET?

To illustrate the importance of refining quantum cryptography, Petruccione referred to a recent statement by the Information Assurance Directorate of the US's National Security Agency (NSA):

"The (directorate) will initiate a transition to quantum-resistant algorithms in the not too distant future... Our ultimate goal is to provide cost-effective security against a potential quantum computer."

The question then, is: how far off are we from the first practical, commercially viable quantum computers that could match PC performance? It could very well be within 10 years – or even less.

The Canadian company D-Wave Systems x built the world's first commercial quantum computer, D-Wave One, as far back as 2007. And yet, prominent scientists such as Umesh Vazirani, a professor at University of California Berkely and one of the founders of quantum complexity theory, are skeptical whether the D-Wave computers (the most recent being the 2X model unveiled recently) are in fact true quantum computers. Nevertheless, in 2013 Nasa and Google announced a partnership with D-Wave Systems to investigate how their computers could be used in the creation of artificial intelligence.

Many universities, institutions and governments are investing sizable amounts of money in quantum computing. In 2013, the UK government announced that it would be investing £270 million towards quantum computing research over a period of five years. The intention was to give the UK, according to the Engineering and Physical



Science Research Council, a world-leading position in the “emerging multi-billion-pound new quantum technology markets”. The money is being distributed between various UK-based quantum technology centres. Many such centres exist across the globe, including Nasa’s Quantum Artificial Intelligence Laboratory (QuAIL), the Australian Centre for Quantum Computation and Communication Technology (CQC²T), the CQT and the Delft-based QUTech in the Netherlands. On its website, QUTech proclaims:

“Quantum science has entered a transformational phase from university-based research to engineering-driven technologies. Seemingly fundamental limitations of quantum systems have recently been overcome. Although significant challenges remain available to create further scientific breakthroughs, we have also reached the point where quantum science is ready for engineering.”

In early October, *Nature* published a study by scientists from the CQC²T who were able to successfully build a two-qubit logic gate in silicon. The significance of this is that quantum computing requires qubits (see below) that can be coupled in a scalable manner to increase processing power. The study suggests that this scalability is now possible. Such advances are why QUTech and others perceive a shift from quantum computing research to actual engineering. Many big names in computers, such as Intel (according to a recent *Forbes* article) are, however, convinced that we are still at least a dozen years out from real, practical applications for quantum computing.

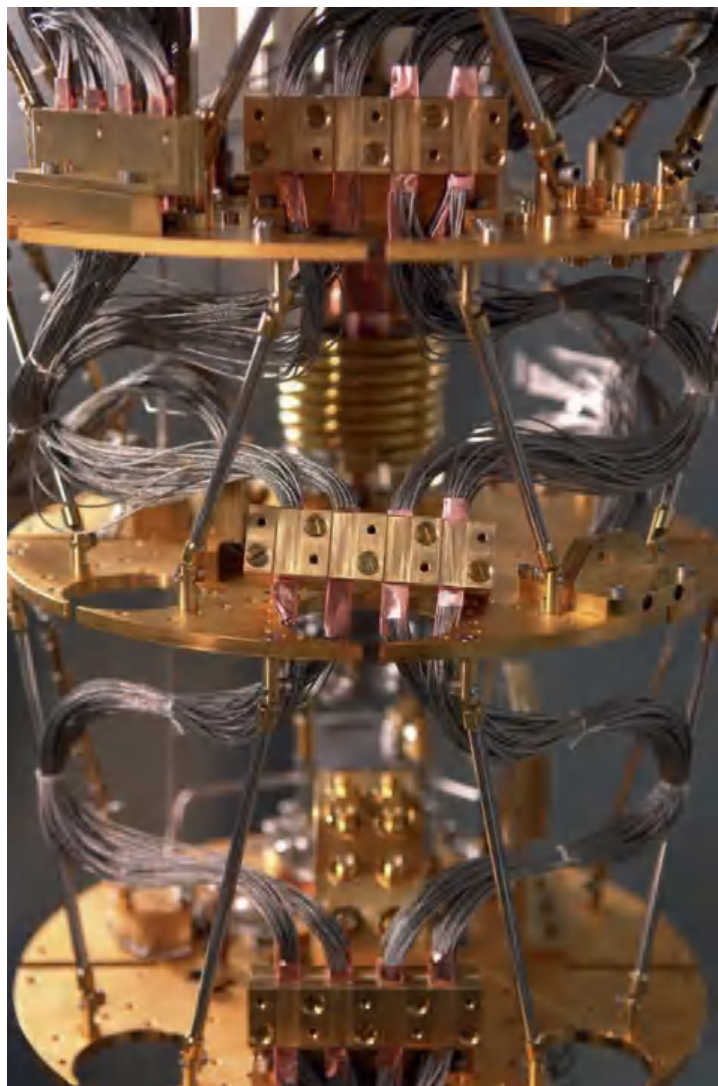
Petrucione admits that quantum computing still has a way to go. The largest number so far factored by a quantum computer is just 143, but he says advances such as the two-qubit logic gate could change the scene fairly quickly. That is why cryptography experts are also looking towards quantum physics for a security solution that can withstand known and future threats in the quantum arena.

Physically, too, quantum computing faces hurdles. One of the most daunting is that quantum micro-processors have to be cooled to almost absolute zero for the quantum effects to work. D-Wave Systems seem to have already solved this refrigeration problem to a sufficient enough degree by sealing the chip in a powerful vacuum. Their 2X model has a processor that uses a lattice made up of 1 000 qubits that is cooled close to absolute zero in a pressure-sealed vacuum.

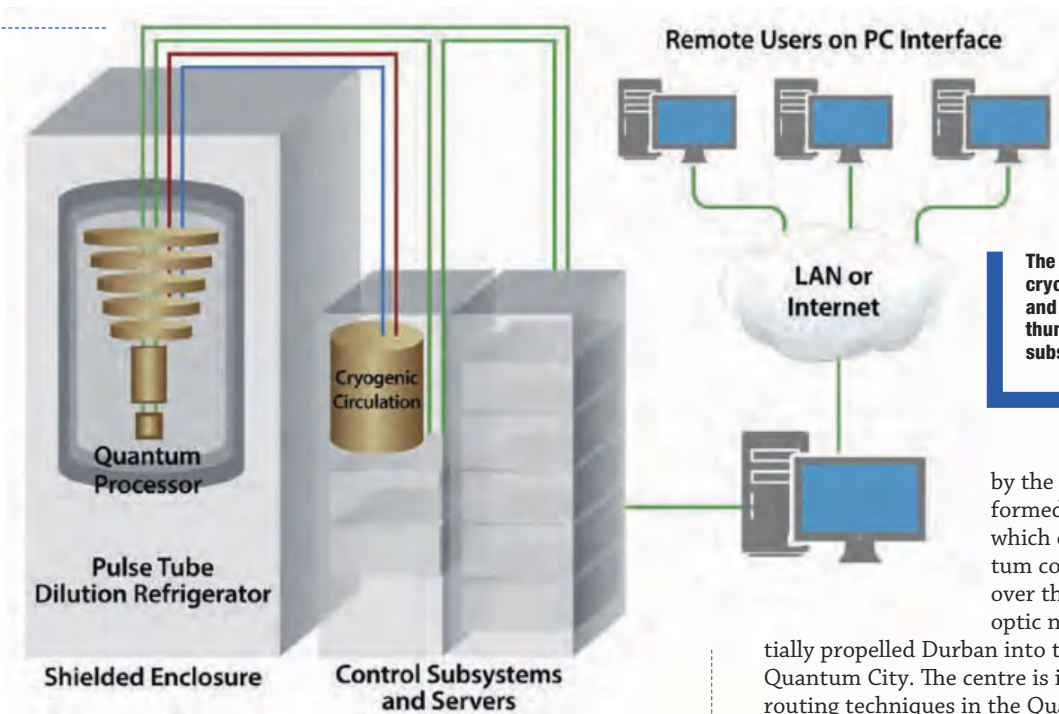
A CRYPTOGRAPHIC CHALLENGE – AND OPPORTUNITY

Petrucione explained that, because quantum computers will be able to factor and solve large, complex number problems very fast and efficiently, most conventional public-key encryption systems that rely on mathematical security based on computational complexity will easily be broken by a powerful new-generation machines. Quantum computers will be able to simply reverse compute private security keys faster than conventional computers, leaving networks and information exposed.

As is often the case, however, the problem also presents the



A cryogenic fridge, top, is necessary to reduce the temperature of the quantum processor package, bottom, to near absolute zero to isolate it from its surroundings so that it can behave quantum mechanically. The “dry” dilution refrigerator used to cool the processor uses liquid helium in a closed-loop cycle.



The D-wave set-up comprises a sophisticated cryogenic refrigeration system, shielding and I/O systems that support a single thumbnail-sized quantum processor, with substantial shielding and isolation in place.

by the eThekweni municipality. This formed part of the QuantumCity project, which entailed the installation of a quantum communication security solution over the eThekweni municipality fibre-optic network infrastructure. This essentially propelled Durban into the position of the world's first Quantum City.

The centre is investigating passive and active routing techniques in the QuantumCity project for implementation into quantum networks.

In 2010, the centre partnered with the eThekweni municipality for the quantumStadium project, providing an ultra high-level QKD system to secure the network linking the Moses Mabhida Stadium with the Joint Operation Centre in the city of Durban during the 2010 FIFA World Cup. The project used the award-winning Cerberis hybrid quantum encryption solution developed jointly by Australia's Senetas Corporation and Geneva-based idQuantique to provide ultra-high data security, including telephone, Internet, video, data and email traffic travelling across the fibre optic link at up to 1 Gigabit per second. It was the first public global event to use a quantum-based encryption solution.

Currently, the centre is working on an optical quantum entanglement source, which will be educational rather than industrial, to help train students in the use of quantum technologies. Through funding provided by the Technology Innovation Agency, centre is also working towards developing a quantum random number generator with the aim of creating truly random bit sequences to be used as a one-time pad encryption key.

Through these projects, Petruccione believes the centre is helping to lead the charge, not only in Africa but also globally, to create QKD security solutions that will protect data when more powerful quantum computers start to come online.

"In the not too distant future, data encryption will have to change completely. Thanks to quantum mechanics, however, many of the solutions are already here – they just need to be perfected, sooner rather than later," said Petruccione.

GUESSING GAME

So, when will quantum computers replace conventional home PCs? No one seems to know. A recent study by a host of quantum experts, including prominent physicist Matthias Troyer, claimed that current quantum computers (including the D-Wave models) did not outperform traditional computers on several key benchmarks. But it's also telling that the European Telecommunication Standards Institute (ETSI) already hosts a quantum industry specification group in anticipation of an expected rollout of quantum technologies.

Whatever the case may be it seems likely that the future of computing, and data security, will involve, sooner or later, a quantum leap.

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solution. The development of quantum cryptography, and specifically quantum key distribution (QKD), has provided cryptographers with a tool that could potentially create a form of security that would at first glance seem unbreakable in conventional terms.

The reason for this is that QKD doesn't rely on mathematical complexity, but presents physical security based on the laws of quantum mechanics. Because of the nature of quantum mechanics, any spy or hacker trying to listen in or intercept information protected by QKD will immediately disturb the quantum system and automatically be detected. Many existing quantum cryptosystems rely on this observer effect. The process of measuring a quantum system in general disturbs that system; thus, QKD enables two parties to produce a shared random secret key known only to them, which can then be used to encrypt and decrypt messages with no threat of eavesdropping.

Of course, things are never that simple. Petruccione pointed to the main challenges of QKD systems: they are fundamentally point to point, require special hardware, covers only key exchange (not authentication or integrity) and still have very limited range and rates of transfer.

Kaspersky Lab also mentions another flaw in a blog post. It seems that, because QKD systems transmit multiple photons to avoid interference and allow long-distance transmission, theoretically it is possible to intercept one photon and analyse its state without touching or disturbing others. Also, hackers have discovered that by "blinding" QKD photodetectors with a powerful laser, they are able to manipulate its readings, which enables data manipulation in QKD systems. These implementation flaws are why a lot more research and development will be needed to create truly "uncrackable" QKD cryptosystems. Large strides have however already been made, both locally and abroad.

STEP BY STEP

Since its inception, the UKZN's Centre for Quantum Technology has come a long way, according to Petruccione. In 2008 it was able to successfully transmit a QKD signal over a distance of 13 kilometres on a standard optical fibre line owned

LIFE 2.0



Innovative Deep Brain Stimulation provides a new lease on life for Parkinson's sufferers – even those who aren't on medical aid

EIGHTEEN SECONDS OF GRAINY VIDEO, recorded in a hospital corridor. Nursing staff flit in and out of shot, making noisy conversation. In the centre of the picture a barefoot man takes half a dozen strides away from the camera. His progress halted by a patient in a wheelchair, he turns and retraces his steps.

Despite the cacophonous soundtrack, you can make out the female voice at 0:07: "I'm so happy. So happy." And 0:13: "A new lease on life." Finally at 0:16 the man turns, faces the camera and cracks a smile: "It feels good," he says.

The man in picture is Willem Mills, who moments before had been unable to walk without support, bolstered by the daily massive doses of meds required to control the symptoms of Parkinson's Disease. Mills is a recipient of a Deep Brain Stimulation implant (the first in a State facility, KwaZulu-Natal's Inkosi Albert Luthuli hospital), a device that has dramatically improved life for tens of thousands worldwide.

At just 26, Mills was one of the unfortunate 5 per cent of people diagnosed with the disease before they turn 40. An active sportsman, he had embarked on a rugby career with the Border Bulldogs. The first hint that something was wrong came through breaking a wrist in a rugby match. After an operation to repair the break, he noticed a tremor in his right ring finger.

Deepening mystery was followed by denial and finally acceptance. "I went to different neurologists hoping every time they would say something else. Two years went by; 11 neurologists later, no one wanted to confirm the diagnosis because I was so young. But eventually I was diagnosed with Parkinson's.

Willem Mills, left, was one of the unfortunate 5 per cent of people diagnosed with Parkinson's before the age of 40, but a 19-hour operation to install a Deep Brain Stimulation device (strip across bottom of page) has transformed his life.



WHAT IS PARKINSON'S?

Parkinson's is a progressive nervous system disease marked by tremors, muscle rigidity and imprecise movement. The disease afflicts mostly older people and though its causes have not been conclusively established, it is linked to degeneration of the basal ganglia of the brain and a deficiency of the neurotransmitter dopamine. There is no cure.



"Then I slowly started coping and made peace with it."

Life with Parkinson's followed a fairly typical pattern of gradual decline. After 10 years, it began to look like the end of the road, with an expected rapid fall-off in the effectiveness of the medication (he was on 36 tablets a day). The window of opportunity for alternatives was fast closing – and in any case, having been boarded and consequently without

medical aid, there wasn't much on offer.

So it seemed like a miracle when Medtronic, which had for some time been exploring opportunities to do the operation at a State hospital, introduced Mills to doctors who had the expertise to perform the delicate operation.

Today, Mills is down to three tablets a day. And he is back playing rugby – even if it's only touch rugby on Sundays with friends.

We caught up with Mills and his attending neurologist to find out how the procedure affected his life and what potential exists for others to benefit.

The surgery, he says, was scary yet exciting.

He was awake the whole time, apart from being put under to make the pocket in his chest for the device and battery. "They told me what they were going to do and I could hear them cutting my



head open, though I couldn't feel anything. I was just thinking about the result... having my life back."

He admits to having been nervous at the thought of going to a State hospital rather than one of the several private hospitals offering the DBS procedure. "But when I got to Inkosi Albert Luthuli hospital, I was immediately put at ease. The running of the hospital, the staff and doctors are friendly and very professional. And the team from Medtronic was excellent."

Mills says there's no comparison between life before and after DBS.

"Six months before the op, I was basically bedridden. I was freezing. My confidence was down. You could see me getting older in front of your eyes. I couldn't walk without holding on to someone or something. I couldn't talk or eat properly."

"Now I live a normal lifestyle. I'm coaching rugby and cricket at Dale College, where I went to school. And I'm playing touch rugby Sundays with my friends again."

What does DBS feel like? "I can't really

describe it," says Mills. "When first switched on, it feels like a shock going through your body. But now, it's not like you feel shock pulses."

The system is programmable, which allows it to be adjusted to provide the exact amount of stimulation required by each person. It can also be adjusted to provide more stimulation as the disease progresses. "I have a remote control to adjust it," says Mills. "Sometimes you need to if you combine medication and the machine... sometimes it depends on your state of mind."

Although DBS is still a relatively new form of treatment, the body of evidence for its effectiveness is overwhelming. Mills's neurologist, Dr Ferzana Amod developed an interest in movement disorders, and subsequently DBS, about four years ago. She opened a movement disorder clinic in recognition of the need that had developed in this area of medicine.

Dr Amod describes the procedure as intense. "The patient is in awake state, with a frame attached to the head. We are just over half a millimetre into the

brain and you have to constantly check progress with the patient. It can take eight hours." In Willem Mills's case, it took 19 hours.

Dr Amod likens the desired stimulation effect on the brain as like driving on a highway. "You don't press the accelerator now and again." Impulses are therefore sent into the brain at a steady rate. "Effects of medication can be erratic. DBS, by contrast, tries to minimise the physiological 'acceleration' in a steady on state."

Nobody really knows how DBS works, she says, just that it does. And, despite its complexity and mysterious action, it has a priceless advantage over conventional medication: the lack of side effects. That's significant when you consider that, pre-DBS, Mills was on a combination of eight types of medication.

Although Dr Amod concedes that the hurdles of cost and expertise remain formidable outside of the private sector, "as State neurologists we have to provide", she adds.

"All that we require is the cost of the device."

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THE SCIENCE BEHIND DBS

DBS uses a surgically implanted medical device, similar to a pacemaker, to deliver carefully controlled, electrical stimulation to a precisely targeted area of the brain. Mills's DBS device was supplied by Medtronic, a world leader in therapeutic/medical technology. The company has pioneered implant technologies that deliver neurostimulation (targeted and regular electrical pulse delivery) to those afflicted with movement disorders, including Parkinson's disease. Studies have shown that deep brain stimulation with Medtronic DBS Therapy components is effective in controlling symptoms of Parkinson's disease that are not adequately controlled with medication. Additionally, DBS is effective in controlling dyskinesias and fluctuations associated with medical therapy for Parkinson's disease.

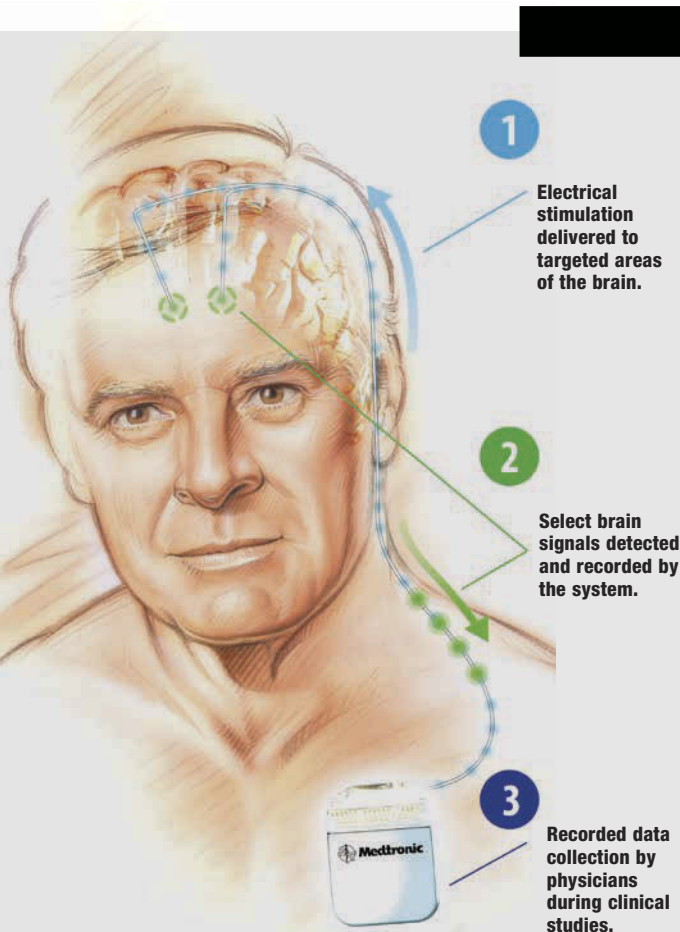
The technology has been approved in Europe since 1993, when DBS technology was first licensed for use in essential tremor. Since then, DBS therapy has been CE mark approved for the treatment of Parkinson's disease (1998), primary dystonia (2003), obsessive compulsive disorder (2009) and epilepsy characterised by partial-onset seizures (2010).

For Parkinson's disease, DBS can deliver targeted stimulation to two possible areas of the brain called the subthalamic nucleus or the globus pallidus interna. Research shows that stimulation to these areas modulates signals within the brain that would otherwise cause symptoms such as stiffness, slowness of movement and shaking.

The Medtronic DBS system is implanted inside the body by a specially trained neurosurgeon. Using sophisticated images of the patient's brain, the exact site to be stimulated is located and thin, insulated wires called "leads" are implanted. These leads are connected through stretchable extensions to a neurostimulator, typically implanted beneath the skin in the chest.

DBS counteracts the abnormal brain messages typical of Parkinson's, alleviating many of the symptoms. It relieves pain, restores bowel function, stops tremors and improves muscle control.

(Source: Medtronic)



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LOOK SMART

Active wear is no longer just about exercise. Next-gen wearables will be able to recognise you, react to your circumstances – and change their shape to keep you cool (or warm).

Wearables used to mean clothing – you know, stuff that you wore to keep you warm in winter and shaded from the sun in summer. Of course, wearables is now shorthand for wearable tech, a catch-all term for items of apparel and accessories that not only serve a decorative purpose, but actually perform some kind of useful function. Think spectacles, wristwatch and, lately, smartwatch and (briefly) Google Glass.

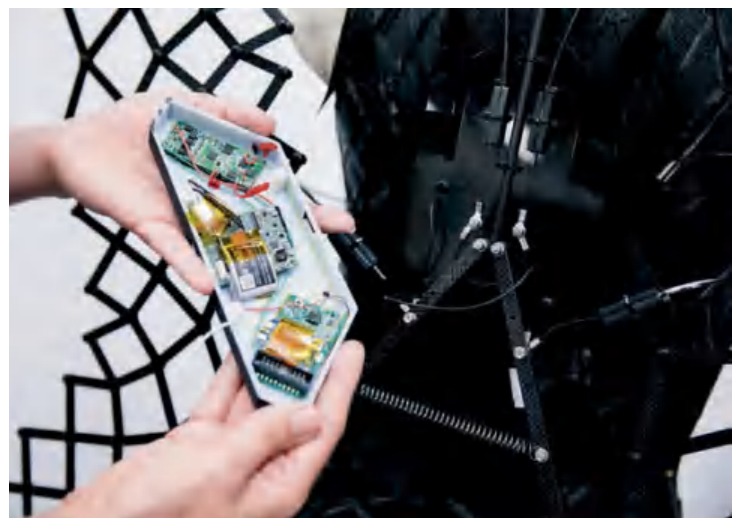
Some wearables have been passive – like clothing that wicks sweat away from your body. Others have been active, like sports shoes that use your footfall to energise and promise to boost your running prowess by means of energy return.

It's in the active end that the action is happening. By year-end, we're told, smart wearables will be able to authenticate a user automatically, enable secure personalised experiences and optimise our daily lives using smart notifications. A lot of that is thanks to technology that has been developed in collaboration with microchip giants Intel using the company's first purpose-built system-on-chip for wearable devices.

It sounds kind of weird to see an item of underwear described as "powered by Intel", but that's exactly the case with the Chromat Aeros Sports Bra. This outwardly normal item of intimate apparel houses Intel's new Curie module. It can respond to changes in perspiration, respiration and body temperature to open or close vents to cool (or warm) the wearer.

At Spring/Summer 2016 New York Fashion Week, Intel teamed up with fashion industry leaders – Milk Studios, WMG-IMG, as well as the designers and creators behind the collections – to show how technology can infuse fashion with intelligence in responsive garments. Intel partnered with sportswear label Chromat for the Spring/Summer 2016 collection runway show, to showcase the sports bra mentioned earlier, as well as a technology-enabled dress that expands and collapses its form based on when the garment senses stress or adrenaline from the wearer. Both garments are enabled by Intel Curie.

The designers say that, by using sensors and an innovative shape memory alloy, the responsive garments reflect a concept known as biomimicry, where Nature is used



Inside Curie

- Low-power, 32-bit Intel® Quark™ microcontroller
- 384 kB flash memory, 80 kB SRAM
- Low-power, integrated DSP sensor hub and pattern matching technology
- Bluetooth Low Energy
- 6-axis combo sensor with accelerometer and gyroscope
- Battery charging circuitry

Brian Krzanich, Intel's chief executive officer, announced the Intel Curie module, a button-sized hardware product for wearable solutions, during his keynote speech at 2015 International CES in Las Vegas, Nevada. The Curie module is a tiny hardware product based on the company's first purpose-built system-on-chip for wearable devices and includes the Intel Quark SE SoC, Bluetooth low-energy radio, sensors and battery charging. It's used in prototypes such as the ventilating sports bra (right and bottom) and shape-shifting dress (opposite).



to solve complex human problems. The Chromat Adrenaline Dress powered by Intel is composed of 3D printed panels and an interlinked, expandable carbon fibre framework. When the wearer senses adrenaline, the dress's framework expands a carbon fibre framework into a stylised hourglass shape.

The Chromat Aeros Sports Bra, made of Lycra, mesh, neoprene and 3D printed frames, leverages shape memory alloy to open vents to cool down the body when it senses heat and sweat. Intel says the two garments illustrate the potential of future integrations of fashion and technology by bringing innovative concepts and aspirations to life.

THE BRAINS BEHIND IT ALL

The Curie module is the first platform of its kind from Intel. At its core is Intel's first purpose-built wearable system-on-a-chip, the Quark SE SoC, which can run for extended periods from a coin-sized battery and features motion sensor, Bluetooth and battery-charging capabilities. Its pattern matching capabilities are fine-tuned to analyse sensor data, enabling quick and easy identification of actions and motions. All that is packaged into a very small form factor and runs a new software platform created specifically for it. The Curie is said to be ideal for "always-on" applications such as health and wellness, social notifications, and sports activities. Because of its tiny size, form factors can range from rings to bags, bracelets, pendants, fitness trackers, even buttons.

To speed the development of wearable products based on Curie, Intel is providing a complete software platform that includes a small and efficient real-time operating system together with reference wearable applications called Intel IQ Software kits. The Software Kits include the embedded software that runs on this module, together with companion smartphone applications and associated cloud capabilities and include:

■ **Identity IQ.** Establishes the identity of the user of the wearable device and enables personalised and secure experiences with services that require personal authentication.

■ **Time IQ.** Aims to improve the efficiency of wearable users' daily routines and accomplish tasks with contextually aware notifications.

■ **Body IQ.** Enables capabilities related to physical activities, including counting steps and calculating calories burned as well as providing data visualisations to help achieve goals.

■ **Social IQ.** Supports social interactions, including communication via phone, social networks and SMS.

Intel demonstrated the first reference design for enterprise wearables, which features enterprise-grade security and consumer-grade usability. The device allows the wearer to authenticate once on a phone or a PC and carry that authentication with them, enabling automatic login when in close proximity.

● Source: *The NewsMarket, Intel*



It's a toolkit.

But you can wear it

The original multitool has moved way beyond its origins as a toolkit that could fit in the palm of your hand. Now Leatherman has created what it calls an industry first: a multi-tool that can be worn on the wrist. The Leatherman Tread, launched in South Africa in October, has stainless steel links that include two to three functional tools each for a total of 25 usable features like box spanners and screwdrivers.

Leatherman President Ben Rivera conceived the idea after a security checkpoint refused to let him through with a Skeletoot. His thinking started with a bike chain bracelet that was gradually workshopped into the Tread. Each complex link is metal injection moulded, customisable with slotted fasteners to allow links to be rearranged or substituted or adjusted for wrist size. Even the clasp is functional with a bottle opener and #2 square drive. Other link tools include a cutting hook, hex drives, screwdrivers, box wrenches and a carbide glass breaker. And yes, there's even an optional watch that is set to become standard on a version of the bracelet in future. Price: R2 700.



From watches to wearables

Fossil's new Q line, created in collaboration with Intel, takes the company that made its name with timepieces into the smartwatch age. Compatible with Android and iOS devices, the new products connect using Bluetooth and incorporate wireless charging. According to Fossil, the Q Grant is a watch that talks to your smartphone, tracks fitness, listens for important messages and then alerts you to e-mails, texts, phone calls and app news. The fitband models in the new line include the Q Reveler, a bracelet that keeps track of how far you run and supplies notifications, and the Q Dreamer.

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CARS

DON'T KILL THE DIESEL

THE EMISSIONS-TEST SAGA ISN'T A THREAT TO VOLKSWAGEN ALONE. IT HAS STRUCK A BLOW AT THE HUGELY SUCCESSFUL IMPLEMENTATION OF A POWER-TRAIN DESIGN – FROM WHICH SOME SAY IT MAY NEVER RECOVER. RUDOLF DIESEL'S BRANCH DESERVES BETTER.

Fallout from the now infamous Volkswagen diesel emissions saga shows little signs of abating. VW share values tumbled, heads rolled – even at the very top – and an unprecedented recall process started. Litigators are putting fresh batteries in their calculators. But the biggest problem of all: the damage done to the image of the modern diesel as a clean, powerful yet supremely economical engine.

And the spotlight is now on other manufacturers to raise the question of whether they, too, have something to hide – which

they naturally deny. It's been acknowledged that EU testing needs to be updated and made stricter, though. Environmental pressure groups claim that manufacturers are paying lip service to the rules. Some even hint darkly at a US conspiracy against European manufacturers.

Roughly half of all European demand for refined products consists of diesel, but already diesel's share in new-car registrations is reported to be falling. On the US market, slow to adopt the European swing to diesel and mistrustful of the smoke-spewing commercial-trucker image, the

thaw of the past few years looks set to return to its earlier chill.

To make modern diesels powerful, clean and compliant with regulations is a costly business. Massive investments in diesel manufacture are now being called into question. There is even potential for a significant shift in the fuel mix churned out by refineries because of lower demand for diesel.

Against this background, the future for diesel looks grim.

Where diesel comes up trumps

There's a lot to like about the engine that Rudolf built. Patented in the 1890s and at first employed in heavy industry and ships, diesels came into passenger-car use only in the 1930s. The fuel itself is more energy-dense than petrol. As for the engine, strong scientific principles underlie its operation, and it has undergone massive, continual development.

How to cheat on your exams

RESEARCHERS AT WEST VIRGINIA UNIVERSITY were just looking for diesel cars to test. It seems a cruel coincidence that the vehicles they ended up with included two VW products. According to information provided by the International Council on Clean Transportation, the cars needed for testing had to be not new, but also had to have relatively low mileage, offer a mix of nitrogen oxides control technology and include mainstream and upscale vehicles.

Eventually two VW vehicles were obtained – with some difficulty, because of lack of availability – from rental agencies and another from a private individual. The VW cars tested were equipped with 2-litre turbocharged version of the company's E 189 engine.

When tested on the road, the cars emitted nearly 40 times the permitted levels of NOx. Eventually, the US Environmental Protection Agency found that many VW cars being sold in America had devices that could detect when they were being tested and doctor their performance to improve their emissions scores.

It's not entirely clear how the system worked. The EPA is reported to have said the engines had computer software that

could sense the car was in the lab, on a test rig, by monitoring speed, engine operation, air pressure and even steering wheel position. This activated a mode that reduced power and thereby lowered emissions. Once on the road, normal performance was reactivated, increasing emissions far above legal limits, possibly to save fuel or to improve the car's driving performance.

Laboratory emissions tests are part science, part thumbsuck because they can only simulate the demands (and inevitably higher emissions) of real-life driving. The West Virginia University research to benchmark on-road testing was conducted on pre-determined test routes using a portable emissions measurement system. This was able to provide a continuous stream of vehicle data signals including pollutant emission rates, velocity, vehicle position, exhaust temperature, and weather conditions.

VW has used two types of tech, both involving considerable cost, to reduce emissions of nitrogen oxides from diesel engines: trapping the pollutants or treating them with urea. While trapping nitrogen oxides reduces toxic emissions, it comes at a cost to fuel economy.

Meanwhile, VW has confirmed that its newer EA288 engines designed for Euro 5 and 6 emissions standards are not implicated.



VW has confirmed that its newer EA288 engine designed for Euro 5 and 6 emissions standards, above, is not implicated in the testing scandal.

Compared with a petrol engine it needs less fuel as a proportion of its air-fuel mixture to run at maximum efficiency so it's economical, too.

It took a combination of circumstances, as well as advances in precision machinery, for diesel to achieve its current dominance, though.

Inherently lower carbon dioxide emissions compared with petrol engines persuaded Europe that diesels were the answer to concern over greenhouse gases. Favourable prices and taxation, plus a healthy lead in diesel technology among

the manufacturers, added up to a boom in the making. Diesel's rise to market dominance seemed a foregone conclusion. From just 10 per cent in the 1990s it stands now at well over half the total of cars sold in Europe.

But diesel's party has been thoroughly spoilt. Besides the VW saga, proposed stricter emissions controls will be costly, requiring technologies such as urea injection or selective catalytic reduction. They

will simply cost too much to be practical in mass-market cars.

The USA's Environmental Protection Agency said that it would order Volkswagen to recall seven of its American models with affected engines. That's about half a million vehicles. Under pressure from German regulators, who are insisting on software changes for affected vehicles, the company has said that it will recall 8,5 million diesel-powered vehicles in Europe. It's possible that hardware changes will be needed, too. About 6,5 billion euros has been set aside as a war chest to cover the recall process, but the full ramifications aren't yet known. The EPA has the power to fine a company up to \$37 500 per

transgressing vehicle, which could amount to about \$18 billion. And that doesn't take into account possible civil litigation, not to mention criminal investigations. The US Environmental Protection Agency was working with that country's Justice Department to determine penalties and in other parts of the world, investigations are ongoing.

Another setback in the PR war is the news that Wards Communications will not consider any Volkswagen or Audi engines for its influential list of the 10 best engines in the auto industry this year. It's reported that four VW and Audi engines (three petrol, one electric) would have been eligible. Meanwhile, VW has already returned three awards won by its disgraced diesels.

As we went to press with this issue, *Auto Express* reported that the car industry had admitted that manufacturers can't meet 2020 diesel pollution targets and want to almost double Euro 6 limits under new tests.

THE GREEN ALTERNATIVE

Roy de Gouveia is a deeply disappointed man. "In terms of the government's planning, biofuel was meant to be available at pumps countrywide from 1 October 2015," he says. But it's not all gloom for biofuels pioneer De Gouveia, a man who has featured on these pages previously. In 2010, we told the story of Biogreen, his Cape Town company that produces biodiesel from waste cooking oil. De Gouveia is finally expanding operations nationwide, with premises at Germiston in Gauteng and Phoenix in KwaZulu-Natal. The company is now getting oil from Pick n Pay, the Spur group and Burger King. Total input currently stands at around 200 000 litres a month and output is about 85 per cent of that, which translates into 170 000 litres.

The thing is, it's mostly not going on the road, even though it should be. "That's unfortunately minimal," says De Gouveia. "Most of my output goes to existing clients."

On the road, those clients include the likes of Cape Concrete for its heavy trucks. It also feeds generators and among its more unusual uses is as fuel for a Truth Coffee's roaster and the Juice Box's pasteurising process.

De Gouveia puts his money where his mouth is by fuelling his own Mitsubishi, Isuzu and Kia bakkies with his biodiesel.

He is particularly disappointed in the lack of progress on the biofuel front for transportation because he helped craft the



This page and opposite: Turning used cooking oil into something useful is a messy business. Biogreen takes in about 200 000 litres of the stuff a month and, by means of processes and machinery that includes a jet reactor, turns out about 170 000 litres of a product that is able to be used on the road and in industry, to drive engines or power a coffee roaster.



South African biodiesel specification, SANS 1935. If anything, he sees the VW saga as strengthening the biofuel movement. "Those who opt for biodiesel are worried about emissions in the first place."

Besides being based on renewable resources, biodiesel doesn't contain the aromatics and other nasties found in fossil fuels, blends easily with regular diesel fuel and causes lower emissions. Producing biodiesel from vegetable oil entails stripping out the glycerol it contains. What's left is vegetable oil methyl ester – biodiesel – a fuel acceptable to modern engines. Crucial to the Biogreen process is a high-efficiency "jet reactor" invented by local biofuel whiz Org Nieuwoudt that involves intense mixing under pressure using varying nozzle sizes.



Biodiesel doesn't need highly sophisticated engines, he adds. "You don't need the common rail diesel to run it."

He says the food-versus-fuel argument against biodiesel made from plant matter is a red herring. Fuel derived from algae could be the answer: "There's space to grow it in the Northern Cape... an area the size of Gauteng could provide enough fuel for the continent. It would need water, but that water wouldn't be adulterated."

He adds: "When Rudolf Diesel conceived his idea, the thinking was to use vegetable oil."

According to a document provided by De Gouveia, Cape Concrete states its satisfaction with its use, for several years now, of Biogreen's product. In addition to that, Biogreen has been helping them in cleaning dirty diesel in their tanks and

setting up a mixing jet reactor on site.

The biodiesel that Cape Concrete uses is different for on-site vehicles compared with road vehicles. They use 100 per cent biodiesel for forklifts, dumper trucks and loaders on site.

On the road, they use a biodiesel/mineral oil mix for delivery trucks ranging from new Mercedes-Benzes to older Leylands.

Mercedes-Benz SA has approved the use of SANS1935-spec biodiesel for use on its trucks at a maximum of 5 per cent of the total. This will not affect service intervals, oil changes, warranty and performance.

As we said, there's a lot to like about diesel. Whether all of that can now stand up to the scrutiny of the legal process and public opinion remains to be seen.

HOW THE OTHER HALF LIVES

YES, YOU CAN DO A ROAD TRIP IN A TOYOTA AURIS HYBRID, BUT WOULD YOU WANT TO? – LINDSEY SCHUTTERS

Working at Popular Mechanics means that I spend a lot of time convincing my wife about things, and you can only imagine how much convincing it took to swap our 7-seat SUV for a hybrid hatchback on a family vacation. To be fair, we don't need the space of the SUV, but have become accustomed to it. And so the boot-inhibiting rear deck was left behind so to accommodate the stroller and some ingenious packing from the wife meant that we even had clothes to wear.

The hybrid system seamlessly switches between the two power plants, but you never get the sense that either is really good on its own. While the added 207 N.m of torque from the electric motor is fun under hard acceleration, the 73 kW and 142 N.m 1,8 litre four pot has an uninspiring whine when put under load.

The Garden Route isn't known for challenging inclines, but the car is mated to a CVT, which enforced a relaxed pace to the journey. On the plus side, the absence of gear jerk meant my 4-year-old could sleep in peace even without the luxury of reclining rear seats – which have become a family car requirement. Where the Auris did come into its own was on the long straights and downhills because nothing coasts as smoothly as a hybrid, and there's the added benefit of recharging the batteries.

A restless infant meant a reshuffling of the seating arrangements with my wife moving to entertainment duty on the back seat and my daughter riding shotgun in her booster seat. The passenger airbag is easily disabled with two turns of the key and the wife was pleased to announce (yes, announce) that the rear legroom was more comfortable than the front. Although this revelation may have something to do with my daughter not requiring much legroom up front.

The 470 km to Knysna revealed the Auris to be a willing cruiser and stealthy stalker of inattentive pedestrians. I was twice forced to take evasive action when someone bounded into the street, not hearing a car, only to squarely face the approaching Toyota.

There's a reason why Toyota sells so many units and it's because of consistent quality. The Auris is very well put together and the interior materials, though not premium, are pleasing even after hundreds of kilometres. Cabin room was adequate for our small family, but I can't imagine where a fifth person would find accommodation inside the cabin on our trip. I did

long for the 8-way electrically adjustable driver's seat in our family car, but managed to find a relatively comfortable position.

On the trip back, however, the fuel efficiency took a knock on the rise from a mean of 250 m above sea level to 750 m.

I know hybrid technology is meant for swarming traffic and not flattening undulating landscapes. I know families are better suited to sprawling across minivans and SUVs, but so many people are captive in the perceived practicality of the hatchback price point. Add the climate-change rhetoric into the equation with escalating fuel prices and suddenly the marketing makes sense.

The reality is much different. I burned through the batteries within 20 minutes of my morning commute to the office, leaving the next half an hour running on the underpowered petrol engine that then had to lug the dead weight of depleted batteries. The luggage area was left exposed to opportunistic locals at our various stops. And, ultimately, the hybrid technology only returned one litre per 100 kilometres better fuel economy than the SUV on the same journey. Frankly I'd spend the extra R60 on fuel and plant a tree when I get back.





PEUGEOT 208 GT LINE AUTO

JUNIOR LION

The updated Peugeot 208 range has been tightened up to offer South African consumers as much value as possible, with just three model variations. The range-topping GT Line, which I drove on the local media launch, also boasts the choice of a five-speed manual gearbox or a six-speed automatic transmission.

I've always been a fan of the 208's small diameter steering wheel with its thick boss, and chunky spokes, but it looks even more the part in the GT Line specification, which adds contoured and perforated ten-to-two hand positions on the rim, brushed alloy-looking trim on the lower spokes and red stitching on the inside of the rim.

The racy theme is continued throughout the rest of the cabin, with the metallic trim found on the shift lever, ventilation outlets, parking brake boot, around the infotainment screen and instrument panel, while the pedals and door handles are finished to the same effect. The stitching continues on the combination seat upholstery and door panels.

PSA's 175-millimetre touchscreen infotainment system relays much of the 208's vital statistics, a good thing too, because I'm never able to see anything on the instrument cluster's digital centre display and be comfortable behind the wheel at the same time. It's one of the easier units to use in the segment, but I loathe that you have to access the infotainment menu to switch the air-conditioner off (the car's default is always on).

On the freeways around the outskirts of Johannesburg, the GT Line's turbocharged 1,2 three-cylinder motor (current International Engine of the Year champion in the 1,0 to 1,4 category) never skipped a beat, overtaking slower vehicles with a prod of the throttle and making spirited getaways from intersections – all to the tune of a hearty growl from under the bonnet. Despite the enthusiastic driving, the turbopetrol sipped around 4,9 litres/100 km of fuel on the launch route. You don't only save at the pumps, because an emissions figure of just 104 g/km of CO₂ means the 208 GT Line is exempt from emissions tax.

The asking price is R289 900 with a three-year/100 000 km warranty and a five-year/60 000 km maintenance plan as standard.



TATA BOLT HATCH XT

THE COMEBACK

Let's face it, the Indica and Indigo never really ranked high on the lists of South African consumers and just a decade later, they're starting to look (and feel) really tired.

But Tata's back with a mission, and that's to target those who want the comfort and reliability of a new vehicle, but aren't willing to sacrifice features despite having to buy down. The Bolt is the Indian firm's answer to those dissatisfied with the current crop of budget segment contenders. The Bolt sets a new standard for the marque in terms of design, with wrap-around headlamps, chromed trim on the grille and on the fog lamp housing up front, with colour-coded door handles and side mirrors along the profile, the latter complete with indicator repeaters. At the rear, there's a blacked out C-pillar, chromed trim on the tailgate, and a faux diffuser panel.

The cabin doesn't disappoint either. A soft-touch facia houses gloss-black panels and a premium-looking touch-screen infotainment system. All of the controls work with reassuring resistance, and even the seating position can't be faulted.

The Bolt is powered by a newly developed 1,2-litre four-cylinder "Revotron" (sounds like a Transformer, doesn't it?) turbopetrol motor that felt strong enough to keep up



with the freeway flow on the way to Zwartkops from OR Tambo. The engine makes use of a nifty ECO and City mode switch, which manipulates ECU to lower the engine's outputs to save fuel. In theory this works just fine, especially in urban confines, but at Gauteng's altitude, this seriously affects the Bolt's performance. I opted to drive in the normal setting, use full throttle openings during the ride and drive excursion, and still managed an average of 6,0-litres/100 km.

More impressive was the Bolt's ride comfort as it wafted easily along the route, which provided an acceptable array of surface imperfections – and this provided by a simple MacPherson strut suspension system and torsion beam rear set-up.

The Bolt is also available in sedan form, and comes in two specification levels – both of which come with a 2-year/30 000 km service plan and 5-year/100 000 km warranty. Price: R142 995.



FORD RANGER XLT THE BEST GETS BETTER

The best-selling bakkie manufactured locally (according to Naamsa's August 2015 report), is enjoying a lot of attention now that the latest model has been released – but not just because South Africa is awaiting the all-new Hilux...

Because that would be taking away from what is quite an awesome bakkie in the updated Ranger. It's been updated significantly in the looks department (not that it was lacking with the outgoing model), with an appearance that makes it seem like it could feel right at home in the USA's domestic "truck" market. The bold new trapezoidal grille makes use of pretty much most of the Ranger's nose, while the revised headlamps integrate neatly on the edges.

In the cabin, there's generous use of horizontal trim elements that create an impression of even more width, while Ford's lauded SYNC2 infotainment system takes pride of place centre-facia and is armed with an eight-inch touchscreen and impressive voice command system that allows the driver to access the control climate, audio and telephone systems at the touch of a button.

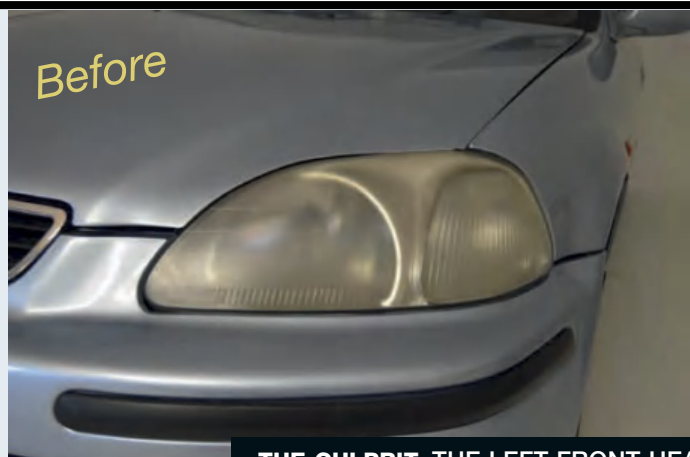
Powered by the trusty five-cylinder 3,2 Duratorq turbodiesel motor with 147 kW and 470 N.m of torque, the Ranger remains one of the most capable off-roaders available locally. What helped even more on a media outing in the Matroosberg mountain range was the strong standard specification, particularly the driver assistance niceties as a shift-on-the-fly transfer case, hill launch assist, and hill descent control (not forgetting that 230 mm



of ground clearance) – all of which helped me make it up and down the off-road route with my pride intact.

The on-road driving was highlighted by a particularly refined experience, a very un-bakkie-like trait. Ford attributes this to not only the use of smarter sound-deadening materials and insulation, but more fine-tuning of the Ranger's suspension system – while the electric power assisted steering has also been tweaked to feel a lot more precise on the open road, and wieldy about town.

There's a five-year/100 000 km service plan as standard as is a four-year/120 000 km warranty, while the service intervals have increased from 15 000 km to every 20 000 km.



THE CULPRIT: THE LEFT FRONT HEADLAMP ON A 1997 HONDA BALLADE.

EASY CAR UPGRADE

OLD FAITHFUL SOMETIMES JUST NEEDS A GADGET TO MAKE IT GREAT. DON'T SELL JUST YET; INSTEAD, TRY THIS TO ENHANCE YOUR MOTORING EXPERIENCE.

The product: Meguiar's Perfect Clarity Headlight Restoration Kit

Price: R586,48

Claim: Makes restoring dull, yellowed and oxidised headlamps quick and easy.

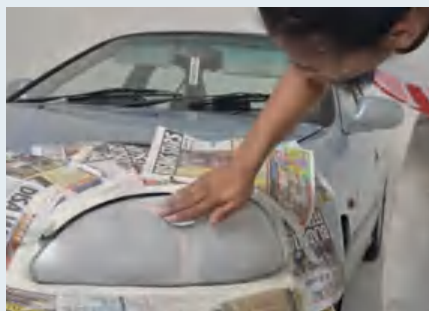
No matter how well you look after your vehicle, the chances are high that, if it's more than 10 years old, then the protective film that covers the polycarbonate plastic headlamps will have degraded thanks to heat from the bulb, UV rays from the Sun, and whatever the road kicks up at it. The result is a foggy appearance that not only looks nasty, but is a potential danger when driving at night.

Step 1. Use masking tape to cover bodywork around the headlamp. Once the headlamp is fully encircled, secure sheets of newspaper for further protection, overlapping the original tape layer by half. **pro tip** – Open bonnet if necessary and use the tip of a pen to round the tape against the headlamp

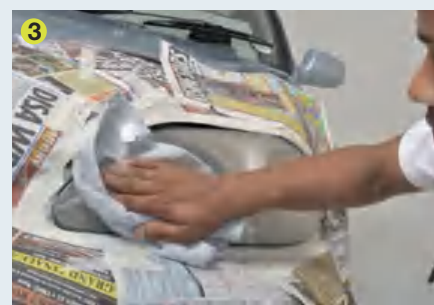


Step 2. Squeeze a R2 coin-sized amount of cleaning fluid on to one of the cleaning pads provided, and start applying to the headlamp in a back and forth or up and down manner until the entire unit is completely frosted over.

pro tip – Lightly mist the headlamp and cleaning pad with some water before applying cleaning fluid.



Step 3. Using a damp cloth (not provided) wipe the headlamp clean, and then use a dry cloth to dry it properly.



Step 4. Holding can about 10-15 cm away from headlamp, spray on the first layer of coating. Allow to dry for five minutes and apply second coat.



Step 5. Remove masking tape and paper and admire!

Verdict: It's well worth a shot.

Want? Order it at www.meguiars.co.za



WELCOME TO THE SMASH LAB

AT THE INSURANCE INSTITUTE FOR HIGHWAY SAFETY, CARS DIE SO THAT YOU CAN LIVE. BY EZRA DYER

The Insurance Institute for Highway Safety in Ruckersville, Virginia, has a history lesson in the lobby. That's where it displays the 1959 Chevrolet Bel Air that it crashed into a 2009 Chevy Malibu to demonstrate the progress in safety over the past 50 years.

The Malibu's front end is annihilated, but its passenger compartment looks practically undisturbed. The Bel Air, however, looks like it cruised straight out of one of those gruesome old safety videos. Cue the voice-over: "Jimmy was on his way to the prom when he decided to try a little street racing..."

Cars are indisputably safer than ever, and that's partly thanks to the work at the IIHS. The organisation is funded by insurance companies, so its mandate is to identify problems and then essentially shame the manufacturers into fixing them. I'd always assumed that all cars met federal safety regulations, so they must all be somewhat equal on the safety front.

Not so. There's a lot of leeway in the federal standard, a lot of variance between an IIHS Top Safety Pick and a car that wears the dreaded "poor" sticker. Unless you're gonna buy a Volvo and call it a day, pay attention to the IIHS's results.

The IIHS typically buys its own cars to test, which is one reason that its ratings don't include any Lamborghinis or Bentleys. Sometimes, though, a car company

volunteers a sacrificial lamb. "Maserati gave us three Ghiblis to test," Becky Mueller, an IIHS senior research engineer, says. In one afternoon they destroyed about R2,6 million worth of cars.

I'm here today because Honda provided the IIHS with a 2016 Pilot for a small overlap frontal test, an extremely brutal type of front-end collision.

In a small overlap crash (as happens by, say, drifting across the centreline on a two-lane road and clipping an oncoming vehicle), the car's crash structure doesn't have much opportunity to absorb the energy. Absent some clever engineering, the driver's side of the car gets peeled back deep into the passenger compartment. The IIHS began conducting the test in 2012, and it's caused manufacturers to rethink the crash structure in newer models. Honda is betting that the Pilot will dissipate the energy without compromising the passenger cell.

And so here we are at what I like to call the smash lab. There's a barrier, 145 tons of concrete and steel. The lights come up and you feel the heat – the lights are so powerful that they'll incur a R600 electric bill for the few minutes it'll take to run the test.

Hollywood-worthy slow-motion cameras start rolling. There's a Klaxon and a count-down. The clock reaches zero and the Pilot speeds into the room at precisely 64 km/h (40 mph), pulled by a cable in the floor.

Crack! In a matter of milliseconds, the car folds itself around the barrier and bounces off, the sharp sound of impact punctuated by the deeper boom of the left-front tyre exploding. The front end is unrecognisable, but the passenger compartment, well, that looks pretty good. The Honda people seem pleased.

IIHS tests are designed to reflect real-world situations, but in one respect the Pilot crash that I witnessed was unrepresentative. In the real world if the car were heading towards a barrier, it would've hit the brakes on its own. It might've also swerved autonomously, thanks to a system called Honda Sensing that initiates emergency braking and steering. The rapid adoption of similar such systems by car-makers has spurred the IIHS to build a whole new outdoor testing facility for safety electronics, portending a day, not far off, when safety depends more on software than steel. After all, the best crash is no crash at all.



MODARRI CARS

THE ONE TO END THEM ALL?

Your kids will develop crucial development, mechanical skills and hand-eye co-ordination with the Modarri car. It's being called the ultimate toy car because it requires a build process with tools and allows for interchangeable design.

Available from The Gadget Shop and Hamley's SA, the Modarri sells for R299,00; optional extras include a body pack (R149) and performance wheel pack (R79).



LEGO FERRARI F40

A GREAT LOOK FOR DAD'S SHELF

The quintessential 80's supercar is being put on another pedestal, if you will. The legendary Danish toy firm has collaborated with the fabled Italian stable to recreate the 40th anniversary of Ferrari in plastic-bricked goodness that's complete with pop-up headlamps, integrated rear wing, louvered rear screen and removable engine. You'll pay a lot less to pull this classic Ferrari into your driveway.

Expect to part with at least R1 200.



● READER COMPETITION ● READER COMPETITION ● READER COMPETITION ● READER COMPETITION ● READER COMPETITION ●

WIN

One of two CITIZEN Radio Controlled Eco-Drive watches valued at R7 499 each.

Designed for globally active business travellers, or anyone with an eye on global business, these watches make it easy to monitor the local times of any two cities of your preference.

Radio-controlled watches automatically detect the correct time by receiving radio waves from a caesium atomic clock, which is accurate to within one second in 100 000 years. Reception areas include Japan, China, North America and Europe.

Two sets of times and dates for any of 26 world cities indicated on the watch face are displayed instantly. The wearer simply pulls the crown and selects the name of the cities with the second hand, and can then easily switch between main time and local time with just one action.

CITIZEN's innovative timekeeping system keeps consistently accurate time in virtually any major time zone. Plus, this timepiece runs on CITIZEN's revolutionary Eco-Drive technology, which uses any light source to power the watch, eliminating the need for a battery.

Competition rules: 1. Entry is open to anyone except employees (and their immediate families) of RamsayMedia and associated agencies. 2. Only one online entry per person. You may enter via SMS as many times as you like (R1,50 per SMS; this service does not allow for 8ta numbers). 3. Competition runs until 31 December 2015. 4. We will draw the winner(s) by 18 January 2016. 5. The prize is not redeemable for cash. 6. Prizes not claimed within 3 months will be forfeited. 7. The judges' decision is final and no correspondence will be entered into. 8. Regrettably, only South African residents are eligible for prizes. 9. By entering this competition, you agree to receive future correspondence from POPULAR MECHANICS. You can opt out at any stage by: (a) Sending an e-mail containing the relevant details with the subject line "opt out" to pmmailers@ramsaymedia.co.za; or (b) Sending an SMS including the word "STOP" to 31699. Standard SMS rates apply. 10. For the complete set of competition rules, see popularmechanics.co.za.



To enter, answer the following question:

How many world cities are indicated on the watch face?

SMS the word **CITIZEN**, followed by the answer, your name and e-mail address to 32697 (R1,50 per SMS; this service does not allow for 8ta numbers), or fill in the online form below. Competition closes 31 December 2015, and the winners will be drawn on 18 January 2016.

CITIZEN

BETTER STARTS NOW

For more information, please view www.citizenwatches.co.za

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to find a product to suit your needs.

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SKILLS

THE MOST USEFUL TOOLS IN YOUR KITCHEN

You may not keep them in the toolbox (in fact, you probably shouldn't), but kitchen knives are just as functional and important to understand as a hammer. Sharper, too.

BY FRANCINE MAROUKIAN

PHOTOGRAPH BY DAVID LAWRENCE

Although there are as many design variations as there are brands, kitchen knives fall into two general categories: western (typically German) and eastern (traditionally Japanese). Their functional differences are based in the regional kitchen cultures they grew from.

Western knives are hefty to meet the demands of classic European cooking, in which the staccato motion of chopping,

dicing and mincing brings the blade edge in constant contact with the cutting board. These knives usually have “softer” blades – reflected in a lower HRC, or hardness measured on the Rockwell C scale (see “A lesson in HRC”) – that are easier to sharpen but less likely to hold an edge. Eastern knives are lighter, with a sharper cutting edge required to perform the delicate precision of Southeast Asian techniques. Their blades typically use a harder steel

alloy that holds that sharper edge, but the edge is more brittle, requiring greater care in handling and maintenance.

Along with HRC, you also want to know what your blade is made of. Basic steel is a mix of carbon and iron, but adding elements creates alloys that are harder or more resistant to corrosion. High-carbon stainless steel does not rust, allows the blade to keep an edge, and gives it a better tensile strength – the amount of stress you can put on the cutting edge before it fails. You'll find varying degrees of elements such as nickel, vanadium, molybdenum, and manganese. (Specific formulas are often stamped on better blades. See below right.) Each has its own influence on edge-holding properties and corrosion resistance.

A LESSON IN HRC

HRC indicates a metal's resistance to force. The number is determined by pressing a penetrator such as a diamond cone into the material, then measuring the resulting deformation or depth of indentation. The standard HRC for better-made German kitchen knives is 56 to 58; some Japanese knives go up to 62.

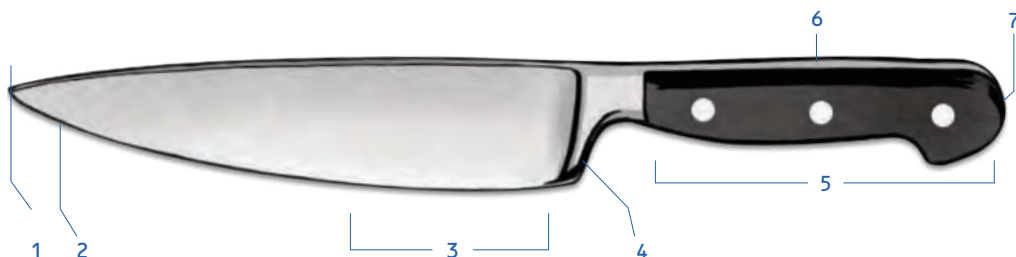


A VISUAL GUIDE TO CUTTING EDGES



THE ANATOMY OF A KNIFE

- POINT** For piercing, like cutting slits in a roast to insert garlic cloves.
- TIP** For more delicate cutting work and as an anchor during mincing.
- HEEL** Where the blade is thickest. Used when more force is required, like when you're cutting through butternut squash or a small bone.
- BOLSTER** This "collar" protects your fingers from the end of the blade when you hold the knife. It also moves the centre of gravity towards the handle, so it's better for high-impact jobs. Classic Japanese knives, especially those used for raw fish, have no bolster, allowing full use of the blade.
- HANDLE** Most western chef's knives have a contoured handle, but there are plenty of variations. The shape you prefer will depend on your grip. Traditionally made for smaller hands, Japanese knives often have an octagonal, round, or D-shaped handle.
- TANG** At one time a full tang, or the visible line of metal continuing back from the blade through the two handle slabs, was the sign of a good knife. It makes the handle feel connected to the blade. In lighter knives, especially of Japanese design, the tang can be shaped like a "rat tail" and inserted half or two-thirds of the way into an enclosed handle.
- BUTT** The most durable part of the knife. If you're desperate (and don't love your knife as much as you should), the butt can be used to pop open a can. Not advocating, just saying.



HOW TO READ YOUR KNIVES

Two examples:

X50 CrMoV15

(PRIMARILY GERMAN KNIVES)

The X=stainless steel.

The 50=0,5 per cent carbon for sharpness.

The 15=15 per cent chromium for stain resistance. Molybdenum (Mo) and vanadium (V) enhance stain-resistant properties, hardness and edge retention.

VG10

(PRIMARILY JAPANESE KNIVES)

The "G" is for gold standard.

At 1 per cent, these knives have more carbon than X50 CrMoV15, so they'll take an edge better. They also have the same 15 per cent chromium for stain resistance. The more common variant, VG1, isn't as durable. Or expensive.

HOW TO BUY KNIVES

By chef Charlie Palmer



Equipping your kitchen doesn't mean buying a presorted set that includes knives you may never use. It's more practical to invest knife by knife, in this order, as your skills and interests develop.

THE CORE COLLECTION

1

Chef's knife



The classic European chef's knife has a curved, rigid blade designed for a rocking motion, often employing the tip as a stationary pivot. Always used on a cutting board, the tall blade provides maximum knuckle clearance. A 20-centimetre blade is standard, but chef's knives are available from 15 to 35 centimetres. (The measurement doesn't include the handle.)

THE GRIP

You hold a chef's knife differently to the way you would hold a pocket-knife. For chopping, the preferred "claw grip" involves pinching the blade between your thumb and forefinger just ahead of the bolster while the rest of your fingers wrap around the handle and out of the way. This provides balance and lets your knuckles guide the blade.

2

Offset serrated knife



An offset handle keeps your hand above the blade, providing leverage and knuckle room for cutting through crusty baguettes and tough-skinned fruits like oranges. Look for a scalloped edge cut on one side instead of jagged saw teeth. That way you can also use this knife to cut delicate things such as tomatoes and soft cheeses.

3

Paring knife or 15-cm utility knife



A lot of people swear by their paring knives, small blades with tapered tips used for precise handheld work. You could do that, or you could use what I do: a midsize Japanese utility blade (pictured). It fulfills most paring-knife tasks but will also handle light slicing jobs and can even be pressed into service as a filleting or boning knife.

SPECIALTY KNIVES

4

Flexible 15-cm boning knife



Used to remove bones from raw meat and poultry. The pointed tip and flexible blade can manoeuvre around the contours of joints and also remove silver skin (connective tissue) and fat.

5

20-cm carving knife



Best for bone-in meat and big birds like your Christmas turkey. The narrow, slightly flexible blade is long enough to work big pieces of meat, and the sharp tip handles the curves around bones. Get a carving fork, too. It keeps the meat in one place.



STUPID OR AMAZING?

THE EDGE PRO KNIFE SHARPENER

We asked Ben Dale, inventor of this crazy-looking sharpener that holds the knife at a precise angle to produce a sharp blade without damaging the cutting edge, to explain why the Edge Pro is better than a whetstone or a steel, and why it's worth R2 250.

No one really should use a steel, those metal rods you see people using to sharpen their knives. All it does is rip some fragments of metal loose on the edge. These fragments are sharp, so they allow the knife to cut better, but only for about 20 minutes, at which point you need to steel again because the fragments have broken off into your cutting board and your food. Each time you use the steel, the edge of the blade gets rounder, and soon you are not able to get any steel to break loose. Then the knife is dead. A whetstone is better, but it's still tricky. It is almost impossible for human hands to make a consistent enough stroke, holding the blade at the precise angle along the grinding surface to get a really good edge. I am as good as you can get, and I still have about 2 degrees of variation in my stroke. Every little bit you're off takes away from the sharpness and increases the chance you'll damage the cutting edge.

VERDICT



TIPS!

STORAGE

Wooden blocks are unsanitary, trapping microscopic bits of food. Plus, the block can damage blades, which are inserted with the vulnerable cutting side down. I keep my knives where I can see them, on a wall-mounted magnetic bar.

CUTTING

Never cut on ceramic, glass or marble. It will damage your knives and dull the cutting edge. Use wood, bamboo and wood-fibre composites – materials with a little more give. – CP

SHOP NOTES

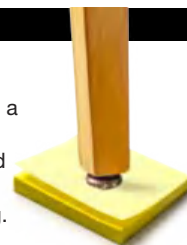


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Easy ways
to do hard
things

POST-IT-PAD SHIM


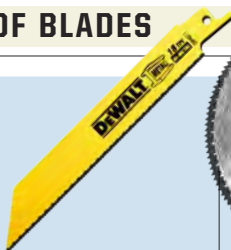

When balancing a wobbly table or chair, grab a pad of Post-it notes. The ubiquitous office product is an ideal shim: it can be fine-tuned by removing individual notes, and paper won't scratch even the softest wood flooring. When in doubt, measure twice, peel once.



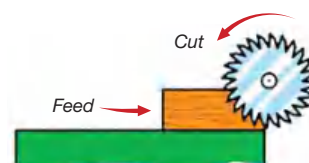
Saw blades: the finer points

There are too many different kinds of saws to count, each with a specific purpose. They all come down to the same thing: teeth cutting material from a surface. Learn how saw blades work and choosing the right saw gets a lot easier.

TYPES OF BLADES

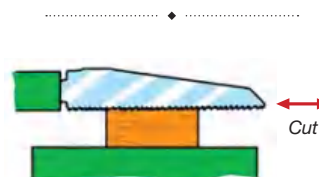
			
	BAND-SAW BLADE	BAYONET-STYLE BLADE	CIRCULAR BLADE
Motion	Teeth move in a line, in only one direction	Reciprocating or orbital	Rotating
Dimensions	Length, measured in inches, and teeth per inch (TPI)	Length, measured in inches, and teeth per inch	Diameter, measured in inches, and total number of teeth
Common blade materials	High-carbon steel, high-speed steel	Bimetal, high-carbon steel	High-speed steel, carbide (teeth)
Saw types	Band saw	Reciprocating saw, jigsaw, sternal saw	Circular saw, table saw, mitre saw
Classic examples	Delta 14-inch band saw	Milwaukee Sawzall	Skilsaw

CUTTING MOTIONS



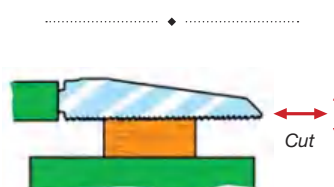
ROTATING

Teeth travel around the circumference of a circle, cutting in only one direction.



RECIPROCATING

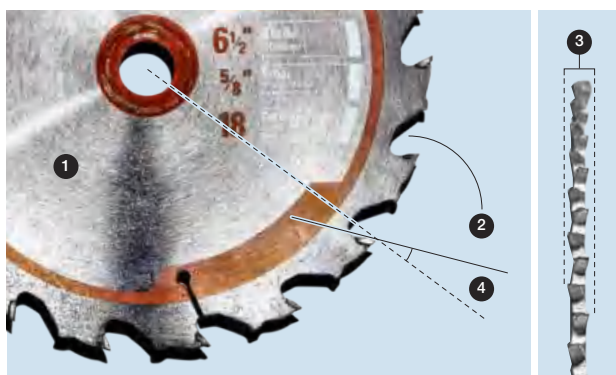
Teeth move back and forth in a line, and can potentially cut on both the push and pull strokes.



ORBITAL

In addition to linear movement, teeth move slightly up and down, describing an oval. Cutting forward and down at the same time produces a faster, but rougher, cut.

TOOTH GEOMETRY



- 1. PLATE**
The body of the blade.
- 2. GULLET**
The space between teeth. Helps clear cut material.
- 3. KERF**
Cut width. Thicker cuts require more power.
- 4. HOOK ANGLE**
Angle of the teeth. Forward rake makes a more aggressive cut.

ON TEETH

A blade with fewer teeth is said to be coarser than a blade with more teeth, and, generally speaking, should be used on softer materials.

WAYS TO CUT A BOARD



RIP

Parallel to the grain



CROSSCUT
Perpendicular to the grain



MITRE
Diagonal to the grain



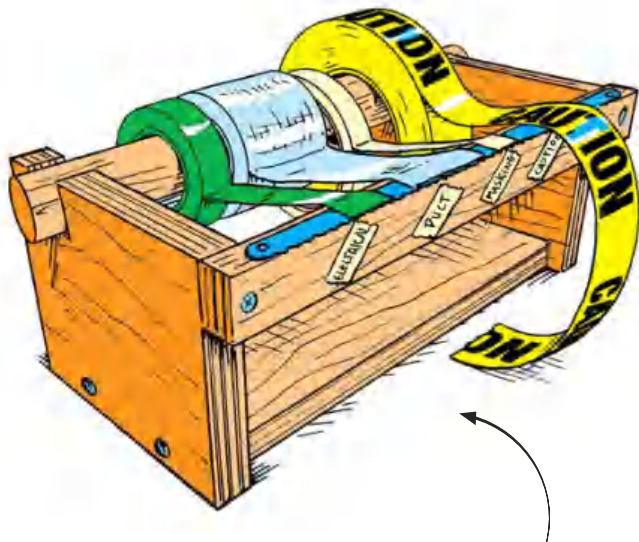
BEVEL

An angle on the edge of the board

FROM
—THE—
ARCHIVES
(1968!)

HOLSTER TOOLS WHEN ON LADDER

An empty bleach bottle is the perfect size to carry a drill or other power tool on a ladder. After emptying the bottle, make an angled cut to take its bottom off. Turn it upside down and bolt it to a ladder's side. It keeps a tool handy, but out of the way.



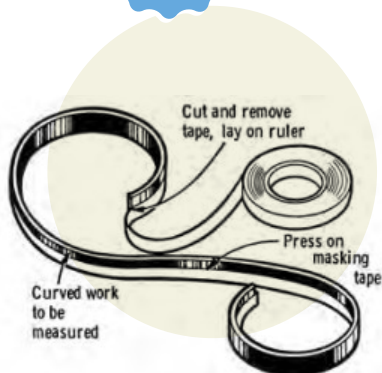
Handy tape dispenser from spare parts

It's time to organise the rolls of tape scattered around the house. Here's the best way: cut a rectangular wood frame from scrap. Find a leftover dowel or length of rod or pipe. Cut it to the width of the wood frame, and cut slots in the frame to hold it. String rolls of tape along your improvised spindle. The finishing touch? An old hacksaw blade fixed on the front edge of the wood frame makes a cutting tool.

FROM
—THE—
ARCHIVES
(1969!)

MEASURE ABNORMAL MEMBERS WITH SOLDER OR TAPE

When cutting a straight material that will be curved in its final use – such as chrome tubing for a toilet supply line or wood for the edge band of an elegant counter – it's difficult to know the exact length of material needed. Figure the measurements with a substitute material. For pipes or tubing, bend solder into the shape needed, then straighten and measure it. To follow the curve of an existing surface, press a strip of masking tape along it, then carefully remove the tape, lay it flat, and measure it.



WIN! with our home workshop challenge

AND ANNOUNCING:

Workshop Challenge No. 4

Accept the **PM Home Workshop Challenge** and a **Makita DHP458ZK Cordless 18V Lithium-Ion Impact Drill Kit**, valued at **R6 386**, could be yours.

THE THEME: IN THE GARDEN

Summertime and the living is easy. And a lot of the time it's outdoors. Whether your garden is the green leafy kind or the austere Oriental kind, there's bound to be a way it can be enhanced with your own efforts. We're thinking daybed, brick braai, water feature, treetop deck, unusual planter, labour-saving device... with just one condition. Unlike Challenge No. 3, this time around you are required to creatively use at least one power tool in putting together your project. Your scope is as wide as the imagination allows.

THE PRIZE:



Makita DHP458ZK Cordless 18 V Lithium-Ion Impact Driver Drill Kit.

This top-of-the-range Makita 13 mm impact driver drill features a battery indicator that displays the remaining battery charge; twin LED lights that illuminate when the trigger is pressed; and three functions – drilling, hammer action and screw driving. The **DHP458ZK** provides plenty of power for demanding tasks, with 21 torque settings to choose from – giving you perfect control and a maximum torque of up to 91 N.m.

This model is extremely compact, with a two-speed metal gearbox and steel keyless chuck. It features a rubberised grip, an extended side handle for greater control, a reversible belt clip for both left- and right-handed operation and a twin bit holder.

Included in the prize are a **Makita DHP458ZK impact driver drill** (supplied in a handy **carry case**) with **2 x 4,0 Ah Makita Lithium Ion batteries** (BL1840, which recharges in 36 minutes) and a **Makita compact fast charger** (DC18RC).

To find out more, visit www.makita.co.za, like Makita on Facebook **Makita-PowerToolsSA** or call 011 878 2600.

Your project will appear in a future issue of **POPULAR MECHANICS**.

Email your plans and a picture of the results, by **13 January 2016**, to popularmechanics@ramsaymedia.co.za.

For full competition rules, see www.popularmechanics.co.za/workshopchallenge

Makita Popular Mechanics



DISASSEMBLY REPORT

ELECTROCARDIOGRAPH

MODEL: GE MAC 2000

NUMBER OF PARTS:

281

PRODUCED:
BANGALORE,
INDIA

TIME TO
DISASSEMBLE:
5 HOURS,
21 MINUTES

NOTES: Muscles are machines, powered by electricity. An electrocardiograph is a multimeter of the heart, with 10 lead wires instead of two. As your heart beats, electrodes on the lead wires pick up the resulting electrical signals from strategic points on your body. These signals are interpreted in three dimensions by a cardiologist – who can literally see your heartbeat.

TURNING IT ON

The MAC 2000 is designed to be adaptable to a variety of hospital environments. Its power supply (16) can work with wall power from a cord through the power inlet (12) or electricity from the on-board 14.4-volt lithium-ion battery (13), which is designed to power the machine for three hours.

Because hospitals have

different systems for organising patient information, the rear-connector-panel cover plate (1) includes ports for connecting Ethernet and flash-memory cards and a bar-code scanner. Or there's always the keyboard (3).

PREPPING THE PATIENT

The electrocardiograph uses electrodes to detect

the 1- to 2-millivolt electrical signals that make the heart contract. Some countries use reusable electrodes, some use disposable electrodes. To accom-

modate both, the MAC 2000 uses lead-wire adaptors. One end of the electrode adaptor clip (6) grips the electrode and the other latches on to a lead-wire adaptor (7). Six electrodes are grouped around the heart and one is placed on each limb, capturing the electricity of the heart-beat in two planes: one parallel to the waist and one perpendicular. An electrolyte gel transmits electricity from the skin to silver plating on the electrodes. The electricity then makes its way up the network of lead wires (8) through the main wire, or patient cable (14), and into the electrocardiograph.

THE EXAMINATION

The real job of the electrocardiograph is to translate the heart's electrical signals into waveforms a cardiologist can interpret to detect problems. That means doing some maths with the signals. When they first enter the guts of the machine, those signals are too weak to work with, so they are sent through an instrumentation amplifier (4) to boost them from millivolts to volts and then through a band-pass filter (4) to remove high and low frequencies, isolating the useful midrange. An analogue-to-digital converter (5) turns the

stronger, clearer signal into a digital value.

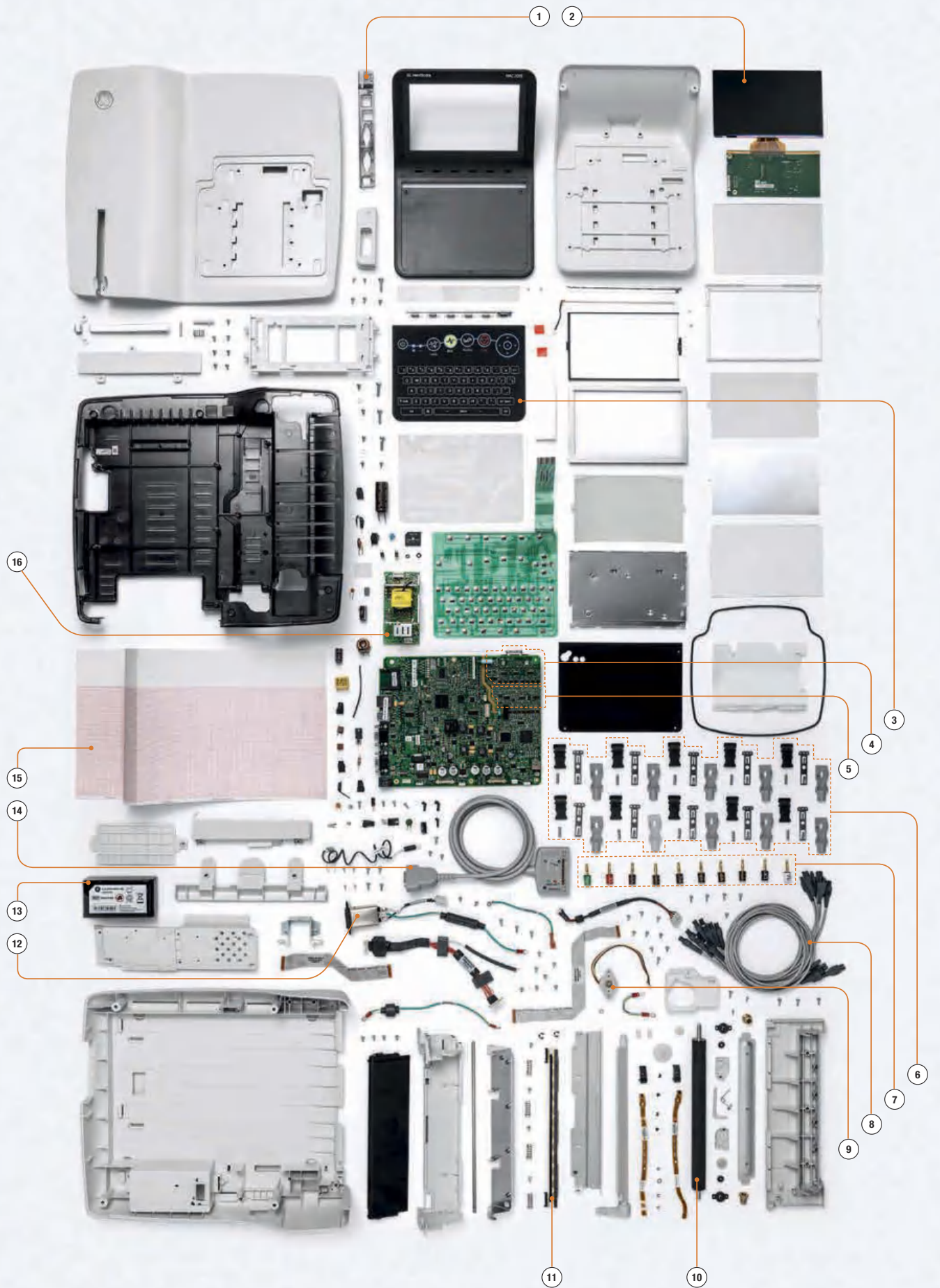
While these digital values are generated by the electrical impulses measured by the ten lead wires, they are used to calculate 12 different leads. Each lead is a calculation of the electrical potential between electrodes, which changes when the heart contracts. Tracking this potential in voltage over time produces waveforms, which are displayed in a 3 x 4 grid on the machine's 175-millimetre LCD display (2).

DIAGNOSIS

Doctors see information from the 12 leads in a report called an electrocardiogram, or EKG. The MAC 2000 prints the report on demand with a printer. Its thermal printhead (11) carries a straight-line array of heater elements, each of which prints when a corresponding transistor is activated. The thermal paper (15) used by the printer has a 1-millimetre grid. The standard scale for an electrocardiogram is 10 millimetres per millivolt and 25 mm per second, but that can be adjusted. To accommodate this, the printhead and a small motor (9) that drives the paper roller (10) are electronically controlled to produce the scale the doctor selects. – KEVIN DUPZYK

A BRIEF GUIDE TO EKG READOUTS





OUR BUILDER
Seven-year-old Seth
Hensinger gets rolling.



MARBLE RUN!

A project to build
with your children.

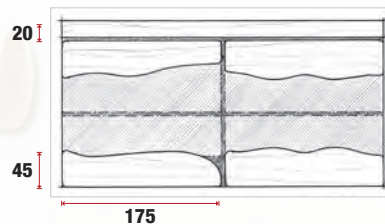
DESIGNED BY
JAMES SCHADEWALD

DIFFICULTY: EASY | REASONABLE | HARD
TIME: 2 hours **AGE:** 6+

PROJECT NOTES

THE CLATTER WILL eventually drive you nuts, but this magnetic marble run is infinitely reconfigurable – and a lot of fun. Finding a mounting surface is easy, considering that most of us have refrigerators in our homes. For the tracks, initially we thought we'd use PVC pipe. Then we tried to cut PVC in half lengthwise. It was tedious and much too hard to do without creating an elaborate jig, so we switched to wood.

The bevelled edge of the track came about through trial and error. Our first attempts were on unbevelled wood. The marble would roll on it, but it wasn't as secure. Occasionally the marble even fell off the track. The 45-degree bevel turned out to be essential – especially as the ramp shapes got more complicated. Finally, there was the matter of how to stop the marble at the end of the ramp. Catching it wasn't an option. (We lost a few under the oven.) We tried a simple box, but that stuck out too far and took more time to build. That's when we decided to create the U-shaped final piece with a peak on either end. There was something satisfying about having the marble fall into an actual box, but really, you just want to finish the work and start playing with this thing.



After you cut a 3/4-inch strip off the plywood, the rest should be used to design shapes for the marble run.

GIVE

Start a child you know on a lifetime of projects with a gift subscription to **POPULAR MECHANICS**. Go to www.magsathome.co.za

Materials

QTY DESCRIPTION

1	quarter sheet of 6 mm plywood
1	bag (40 pcs) button magnets
1	bottle carpenter's glue or craft adhesive
1	bag marbles
1	60-, 80-, and 120-grit sandpaper

Instructions

● parent only
● parent and kid
● kid only

1. After an adult rips a 20-millimetre-wide strip from the plywood, use the rest for drawing ramp shapes – straight lines, rolling curves, ski jumps. Be sure to make one that has a lip on both ends. This piece will catch the marbles at the bottom of each run.
2. Clamp the plywood to a workbench and use a jigsaw and a curve-cutting blade to cut out the ramp shapes. Smooth off any rough edges of the pieces using 80 and 120-grit sandpaper.
3. Crosscut the 20-millimetre strip into spacer blocks, which will go behind your ramp pieces. Using a simple and inexpensive hand mitre saw (such as the Stanley 20-600, pictured) enables younger woodworkers to participate.
4. Glue two spacer blocks and magnets to the back of each ramp. You can use more for larger pieces. Be sure that the blocks are glued so that they don't project out over the edge of the ramp and interfere with the marble as it rolls.
5. Place a board and a weight of some kind on top of each ramp and the spacer blocks to provide pressure and a better glue bond. Allow the glue to dry for a couple of hours.
6. Bevel the back edge of each ramp using 60- and 80-grit sandpaper wrapped around a block of wood, or use a rubber sanding block. The bevelled edge provides a secure track for the marble to roll in.



1



2



3



4



5



6

POPULAR MECHANICS' senior home editor solves your most pressing problems.

BY ROY BERENDSOHN



Q

The crack in the drywall of our upstairs hallway comes back no matter how many times I patch it. What's the right fix?

A Seasonal cracks in dry-wall and plaster are tough to repair. As they open and close, one of two things happens: the surface around the crack crushes and grinds the patch material or it pulls it apart, ripping the material away from the wall or ceiling surface. You need a super-flexible material and one that can bridge a wide gap. I've used **DAP Elasto-Patch** with good results. The material is about the consistency of yoghurt, and you can apply it with a **15-centimetre joint-taping knife**. Although it's pretty simple to use, it'll take you a few tries before you can produce a smooth finish.

Before you patch, use a **painter's 5-in-1 tool** to rake out the former repair materials. Then scoop out the patch and spread it on in thin layers. Wipe off any excess (you won't be able to sand it down like joint compound), let the patch dry, then paint.

Q What's the best way to stop the toilet in our wood-frame holiday home from rocking? I've tightened the bolts at the base, but it's still happening.

A This is usually caused by a rotting subfloor. First, shut off water to the toilet and

pull it out. If it is the subfloor, you'll have to replace the portion that's rotted, the flooring, the toilet-mounting flange, and the wax ring, which makes the watertight seal between the toilet and the pipe. (If your floor is concrete, you might get off easy and all the toilet will need is a new mounting flange. Other-wise, you might

have to cut out a chunk of concrete and install a new closet bend, the cast-iron pipe below the toilet, and a mounting flange.) But let's say this is a minor plumbing skirmish, not all-out war. Suppose you can see no evidence of a leak

and you don't see a rotted subfloor from below – it's unlikely, but you never know. In that case, buy a pack of toilet shims, small plastic wedges that come four to a pack. Loosen the anchor bolts, shim the toilet so it's level, tighten the bolts, cut off the excess part of the shim below the toilet using a hacksaw, then caulk.

Q I have an above-ground oil tank that's 20 to 30 years old. Every so often, it drips. The liquid looks like water, but feels a little oily. Is this condensation or a leak?

A Chances are pretty good that you've got a slow leak. In fact, given the age of

the tank, it's almost certain.

Every fuel-oil tank will have some water and sludge at the bottom. The fuel floats above it, like an oil slick. This water leads to rust that will first form a pinhole, which causes an intermittent leak exactly as you describe, usually on the bottom of the tank's curve, or belly. From there it can turn into a steady leak. A simple way to confirm this is to place a bowl under the tank and let it catch the drip for a few days. With enough liquid accumulated, you'll probably be able to tell immediately if it's oily water from the bottom of the tank. Some oil companies do tank replacements but there are also firms that specialise in this kind of repair work. They clear the tank of oil, leaving some waste oil, sludge, and water that they dispose of. They replace the tank and sometimes the oil lines leading all the way to the boiler or furnace. The new tank may be a simple single-wall model, a double-wall, or even a tank within a leakproof enclosure. Replacement costs depend on the possibility that contaminated soil from the area surrounding the tank may have to be dug up and replaced. This doesn't often happen with above-ground tanks, but it's possible. And expensive.

THE
30-SECOND
PAINT
PRIMER:
BRUSH
STIFFNESS



STIFF
BRUSHES



- ▶ Best for cutting in, a method of flattening out the bristles of the brush that allows you to create a clean line against a wall or a piece of trim.
- ▶ Carry more paint at one time.
- ▶ Leave a rougher finish than soft brushes, so keep the painted area as small as possible.

SOFT
BRUSHES



- ▶ Leave a smooth, finished surface.
- ▶ Better for stain and clear finishes – thinner liquids that stiff brushes have a tendency to flick.
- ▶ Useful on ornate surfaces with multiple layers, because the bristles can get into the nooks and crannies easier. **PM**

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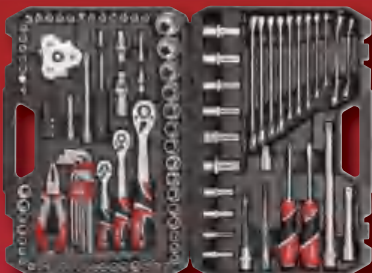
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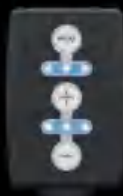
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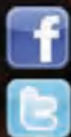
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WINNING TIP

COMPRESSOR ON THE CHEAP

I often end up back at my local bike shop after buying a new tubeless tyre that I find I am unable to fit properly. The usual problem is that the tyre does not seat well and leaks air because there is not enough pressure in a normal bike pump to inflate it. Using a CO₂ "bomb" can work, but sometimes not, and after two or three attempts that's R60 down the drain.

My solution was to obtain a discarded empty refrigerant container from the local air-conditioning company. To this I attached rubber hose with a Y joint. One length of hose has a car tyre valve on the end and allows air in; the other allows air out via a regulator valve to control the air flow, terminating in a normal bike/car pump thumb valve. The rubber hose and clamps came from my local gas shop and cost a few rand. The car tyre valve came from a local tyre shop for free, as was the thumb valve off an expired pump.

The container can be pressurised to say 5 bar, either by pumping with a bicycle pump (hard work!) or by going to the garage and using their air hose. You can also use a small portable electric car tyre pump. Suddenly I had my own engine-less compressor in the garage able to blow up and seat a 29-inch tyre in five seconds!

A further tip: removing the core of the tubeless valve will enable a tyre to be inflated much quicker. You just have to be quick getting your finger over the end when you take the thumb valve off and deftly screwing the core back in before all the air escapes. Practice makes perfect.

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GET IN LINE

It can sometimes be a mission getting drill holes for wall plugs in the correct position when hanging pictures or photos in frames that use more than one hook for hanging. Here's my solution. Start by using a spirit level to draw a 20-centimetre line on the wall, more or less in the centre of where the picture will hang, and mark the centre of the line. Then, turn the picture wrong side up and stretch some masking tape along and over the hanging hooks, marking the

centre of each hook with a pen. Also mark the centre of the masking tape, which will align with the centre mark on the wall. Now place the marked masking tape on the level line on the wall and use a punch on the marked spots. Drilling through the tape will avoid paint peel and rough edges. The punch indents will make sure that you drill exactly where you want.

HAYDN JONES
BY EMAIL

KEY SOLUTION

Allen keys are always falling apart, hard to find, or missing. To solve this problem, I have a magnetic knifeholder to keep them in order. If yours are plastic and therefore not magnetic, use a thin strip of polystyrene covered in tape with holes to hold them in place.

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Send us your best home, garage workshop and general DIY hints – and win! This month's winning tip will receive a Makita DUB182Z 18V Lithium-Ion Cordless blower kit worth R3179. The Makita DUB182Z is a small, compact yet powerful blower that is a really handy addition to any household or workshop. This model is perfect for the smaller jobs such as clearing dust and bits from paving; cleaning up the garage and work bench; and any other small to medium tasks. The DUB182Z has three air volume settings: low, medium and high. Its net weight is 1,7 kg and with the removal of the front nozzle it is compact enough to fit into a large toolbox. The blower delivers a no load speed of 0 – 18 000 r/min, an air pressure of 5,4 kPa and an air volume of 2,6m³/min. You can also turn your blower into a mini vacuum by removing the nozzle on the front, replacing it with a Makita dust bag (available as an accessory) and then attaching the nozzle to the air intake. In this instance the DUB182Z is supplied with a 1 x 18V Lithium-Ion 3,0 Ah BL1830 battery and the DC18RC fast charger. Charging takes approximately 22 minutes and this should keep your blower powered long enough to complete a 10 – 15 minute task depending on the setting used. For further info on Makita Power Tools, visit www.makita.co.za or find us on www.facebook.com/MakitaPowerToolsSA.

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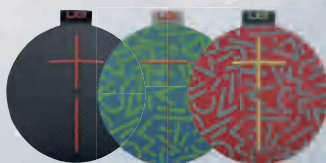
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**UE BOOM 2
R3499**

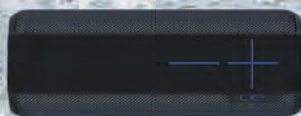
(91308, 91309, 91310, 91311) **MS**
Up to 15 hours battery life



Freakishly amazing sound. Musical mayhem on the go.

**UE MEGABOOM
R4999**

(91312) **MS**
Up to 20 hours battery life



ue ultimate
ears

**EXCLUSIVE TO INCREDIBLE
CONNECTION ONLY**

$$\rho\sqrt{\sigma}m/5\Sigma$$

Education brings promise

Investec Promaths and Bursary programmes are celebrating 10 years of believing in more.

Together with the commitment of our partner organisations, we have given more time, more support and more attention to promising students and learners in order to equip them for the bright futures they deserve. This initiative has grown enormously over the past decade and has all the right elements to continue to produce out of the ordinary results in the future.

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